AN 16-30USM26-1

Handbook
Operating Instructions

FREQUENCY METER AN/USM-26

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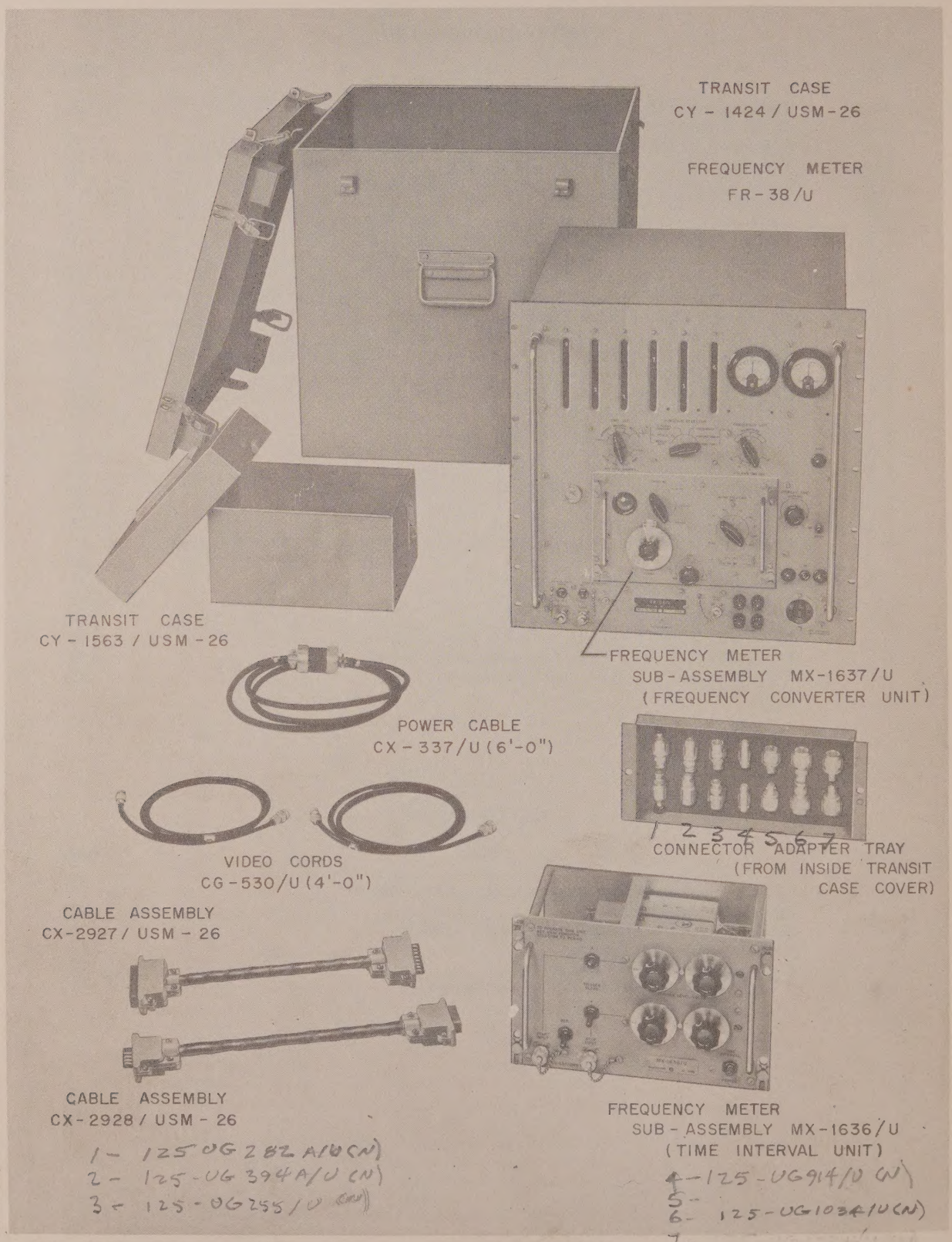


Figure 1-1. Frequency Meter AN/USM-26, Equipment Supplied

SECTION I

GENERAL DESCRIPTION

1-1. PURPOSE OF HANDBOOK.

1-2. The purpose of this handbook is to describe the general use and application, basic operating principals, installation and detailed operating procedures for the Frequency Meter AN/USM-26. Supplementary information pertaining to this instrument is contained in the following publications:

Handbook of Service Instructions	AN 16-30USM26-2
Handbook of Overhaul Instructions	AN 16-30USM26-3
Illustrated Parts Breakdown	AN 16-30USM26-4

1-3. PURPOSE OF EQUIPMENT.

1-4. Frequency Meter AN/USM-26 is a precision instrument that automatically measures frequencies to 100 megacycles and automatically displays its answers in digital form on an eight-place panel indicating system. In addition to making direct measurements of frequency, Frequency Meter AN/USM-26 also measures period (time of one cycle of periodic wave), time intervals, frequency ratios and total events, and may be used to count random events such as those encountered in nuclear work. Table 1-1 summarizes the measurements that can be made with the equipment. The equipment further includes a self-check feature that enables the operator to verify the proper operation of the equipment for most types of measurements.

1-5. Because of the accuracy with which it measures frequencies, the AN/USM-26 equipment can be considered to be a new type of secondary frequency standard that replaces more elaborate installations of conventional precision frequency-measuring equipment. For example, the meter has been found particularly useful for frequency measurements in quartz crystal grinding work as well as for general laboratory-quality frequency measurements. Other typical frequency-measurement applications for the equipment include calibration of transmitters, oscillators, signal generators, etc.

1-6. In combination with tachometer generators or other suitable transducers, the equipment can be used to make precision tachometry measurements. In tachometry work it is particularly useful for measuring high speed devices.

1-7. Time measurements that the equipment will make include pulse length, pulse interval, time delay, etc.

1-8. Since the indicating system in the equipment presents the measured frequency in up to 8 significant figures, the equipment is especially useful for measuring very small frequency changes, such as are encountered when making measurements of frequency stability of oscillators and similar frequency generators.

1-9. EQUIPMENT SUPPLIED.

1-10. The equipment supplied with Frequency Meter AN/USM-26 is shown in Figure 1-1 and listed in Table 1-2. The main components of the Frequency Meter AN/USM-26 are shown in Figures 1-2, 1-3, and 1-4. Figure 1-2 shows the Frequency Meter FR-38/U, the actual frequency-measuring component. Figures 1-3 and 1-4 show the plug-in units Frequency Meter Subassembly MX-1637/U and Frequency Meter Subassembly MX-1636/U, respectively. These plug-in units are commonly referred to by names descriptive of the functions performed by each, i.e., Frequency Converter Unit (MX-1637/U) and Time Interval Unit (MX-1636/U), and these names will be used hereafter in this handbook.

Table 1-1. Measurements Made by Frequency Meter AN/USM-26

1. FREQUENCY	10 cps to 100 megacycles. The frequency can be regular, as with electrical frequencies, or random, as with nuclear particles. Maximum pulse resolution is 0.1 microsecond for double pulses, 0.2 microsecond for triple pulses.
2. PERIOD	100 microseconds to 100 seconds (0.01 cps to 10 kc). A panel switch also permits measuring the average of 10 periods to obtain greater accuracy.
3. TIME INTERVAL	1.0 microsecond to 10,000,000 seconds. An adjustable "threshold" feature permits starting and stopping the measurement with signals of pre-determined amplitude and polarity.
4. TOTAL EVENTS	1 to 100,000,000 events. Maximum pulse resolution of 0.1 microsecond when the unit is used as a high speed scaler and totalizer.
5. TIME OR FREQUENCY RATIOS	100,000,000:1 maximum. The lower of the two frequencies can be as high as 10 kc; the higher can be as much as 10 mc.

Table 1-2. Equipment Supplied

Quan. per Equip.	Item	AN Type Designation	Overall Dimensions (ins.)			Wt. lbs.
			Ht. or Lgth.	Width	Depth	
1	Frequency Meter	FR-38/U	19-7/32	19	18-5/8	109
1	Frequency Converter Unit	MX-1637/U	6-3/8	10	6-1/8	5
1	Time Interval Unit	MX-1636/U	6-3/8	10	6-1/8	4
1	Transit Case	CY-1424/USM-26	22-1/2	23-3/4	23-1/4	41
1	Transit Case	CY-1563/USM-26	8-1/8	12	7-7/8	5
1	Power Cable	CX-337/U (6'0")	72			0.6
2	Video Cord	CG-530/U (4'0")	48			0.2
1	Test Cable	CX-2927/USM-26	13-1/2			0.4
1	Test Cable	CX-2928/USM-26	13-1/2			0.3
2	Connector Adapter	UG-201A/U	1-5/16	25/32		0.1
2	Connector Adapter	UG-255/U	1-11/32	5/8		0.1
2	Connector Adapter	UG-273/U	1-5/16	23/32		0.1
2	Connector Adapter	UG-282/U	2-1/8	5/8		0.1
2	Connector Adapter	UG-349A/U	1-9/16	19/32		0.1
2	Connector Adapter	UG-914/U	1-9/32	7/16		0.03
2	Connector Adapter	UG-1034/U	1-1/2	25/32		0.1

1-11. All components of this equipment except the Time Interval front panel plug-in unit are housed in the large transit case CY-1424/USM-26. The Time Interval front panel plug-in unit is housed in the smaller transit case CY-1563/USM-26.

1-12. EQUIPMENT REQUIRED BUT NOT SUPPLIED.

1-13. No equipment is required which is not supplied.

1-14. GENERAL ELECTRICAL CHARACTERISTICS.

1-15. The actual frequency-measuring component of the AN/USM-26 equipment is Frequency Meter FR-38/U. This instrument measures frequencies from 10 cycles to 10 megacycles per second as well as the period (1/f) of frequencies from 0.01 cps to 10 kilocycles per second. To extend the range of its measurements, however, the FR-38/U Frequency Meter is designed for use with either of two front panel plug-in units which are part of the equipment supplied.

1-16. The first plug-in unit, the Frequency Converter Unit shown in Figure 1-3, extends the upper measurable frequency from 10 megacycles to 100 megacycles. The second plug-in unit, the Time Interval Unit, shown in Figure 1-4, permits measurements of time intervals between two electrical events or between physical events that can be converted into electrical pulses. Time intervals as short as 1 microsecond or as long as 10,000,000 seconds can be measured.

1-17. The accuracy of the FR-38/U when measuring frequencies between 10 cycles and 10 megacycles is ±0.0002% ±0.1 cps for an input signal of 0.2-volt rms or more. When using the Frequency Converter plug-in unit, frequencies to 100 megacycles are measured with the same accuracy. The voltage sensitivity of the equipment in the 10 to 100 megacycle range is increased by the video amplifier of the Converter unit to 0.02-volt rms.

1-18. The accuracy of the FR-38/U when measuring the period of sine wave frequencies up to 10 kilocycles is ±0.03% for input signals of 1-volt rms. Greater accuracy can be achieved for period measurements when higher signal voltages are used.

1-19. The Time Interval plug-in unit enables the instrument to measure time intervals from 1 microsecond to 10,000,000 seconds. These measurements are accurate within ±0.0002% ±0.1 microsecond, provided the rise times of the start and stop signals are negligible compared to the interval being measured.

1-20. A threshold feature is designed into the instrument to simplify measurements of time intervals. This feature permits measurements to be started and

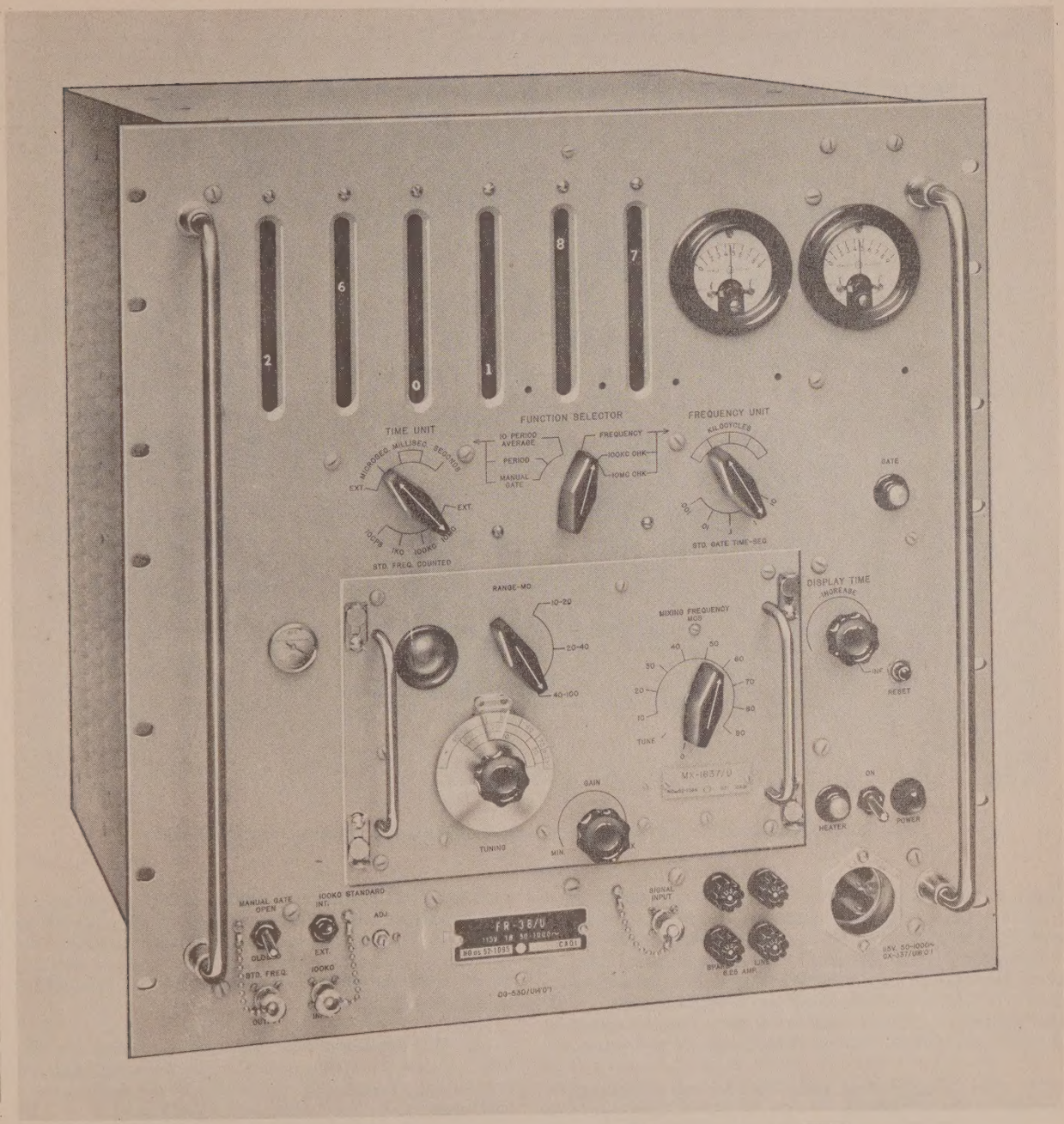


Figure 1-2. Frequency Meter FR-38/U

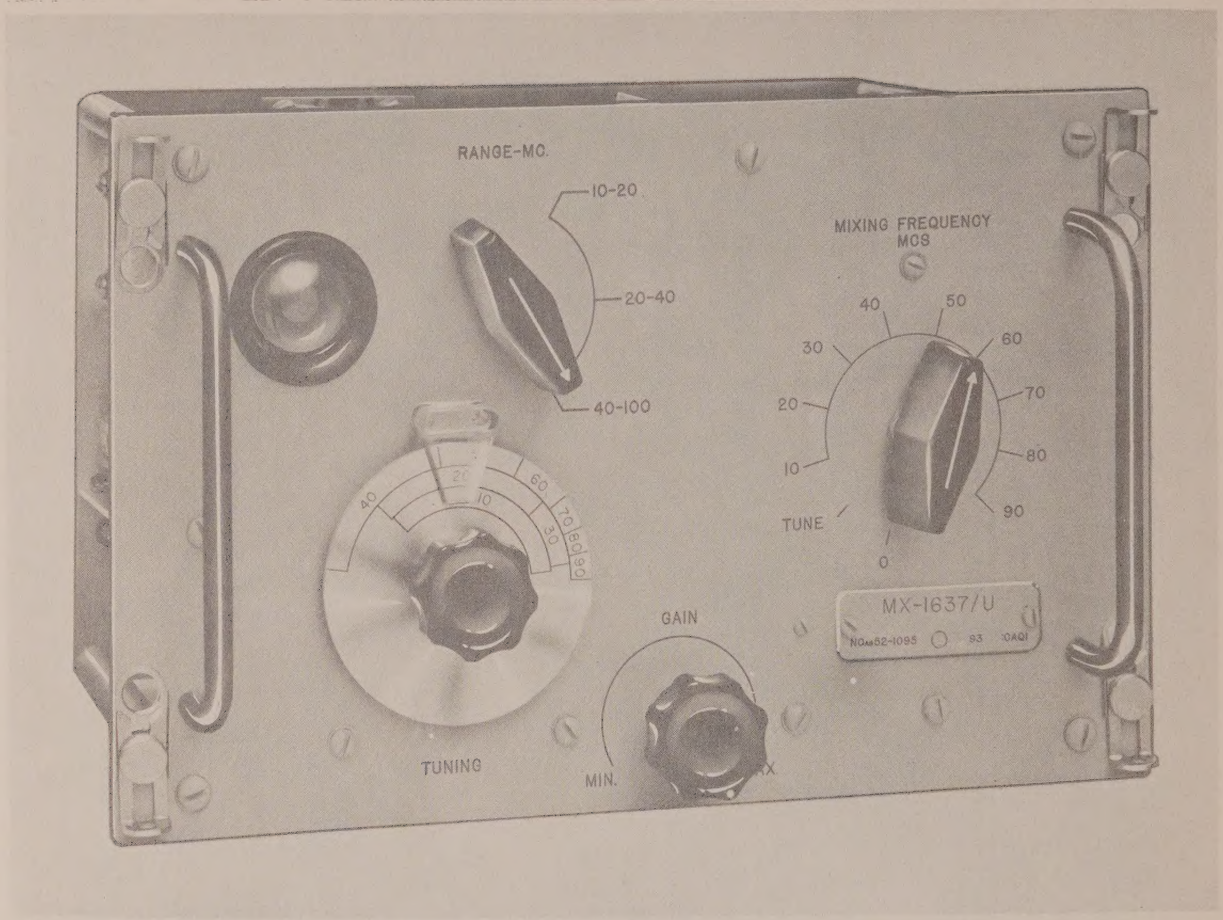


Figure 1-3. Frequency Meter Subassembly MX-1637/U (Frequency Converter Unit)

stopped, independently, from either positive-going or negative-going signals. In addition, the voltage levels at which the measurement is started and stopped are independently adjustable from -200 to +200 volts. This arrangement permits nearly any type of signal to be used for starting or stopping the measurements and also permits measurements to be made from one part of a waveform to another part of the same waveform.

1-21. The complete specifications for the equipment are set out in Table 1-3.

1-22. BASIC OPERATING PRINCIPLES.

1-23. Frequency Meter FR-38/U uses a new type of frequency-measuring circuit known as a frequency counter. Figure 1-5 shows the basic circuit arrangement. The frequency to be measured is passed from the input terminal to an electronic gate whose opening and closing is controlled by a precision time base generator. When the gate is open, the frequency to be measured is applied to a series of digital type counter circuits. When the gate is closed, the counters visually display the total number of cycles applied while the gate was open. Since the precision time base generator holds the gate open for an accurately-known interval of time, the displayed count has the dimension of frequency, i.e., total number of cycles divided by time. Although the displayed value could be given directly in cycles per second, the illuminated decimal point in the FR-38/U is arranged so that the display is directly in kilocycles.

1-24. To measure period and time intervals, the FR-38/U uses a variation of the arrangement it uses for measuring frequency. Referring to the dashed lines in Figure 1-5, the frequency whose period is to be measured is used to open and close the gate, while one of the frequencies generated by the time base generator is applied to the gate input. The arrangement is such that the gate is opened by one cycle of the frequency to be measured and closed by the succeeding cycle. The counters thus indicate the number of cycles of the time base generator that occur during one period of the frequency to be measured. The frequencies obtained from the time base generator have been selected so that the measured periods will be displayed in direct-reading units of time, i.e., seconds, milliseconds, or microseconds.

1-25. Provision is also made in the circuit so that a measurement can be made of the average of 10 periods

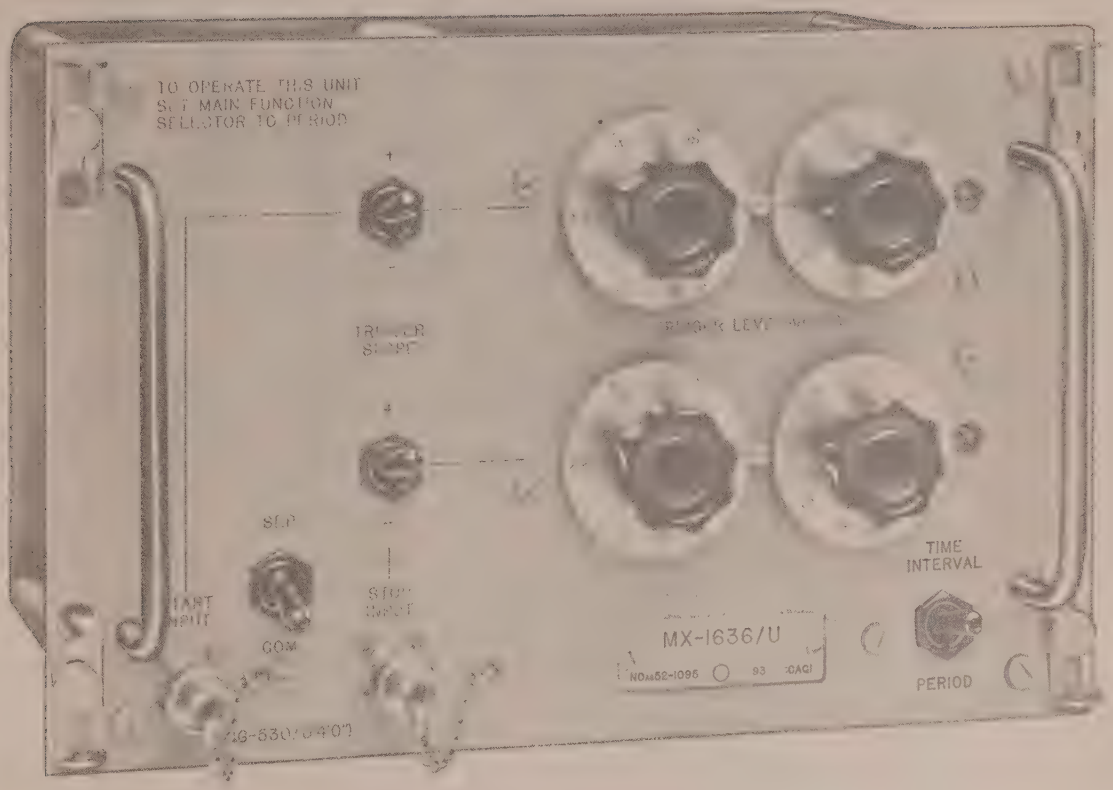


Figure 1-4. Frequency Meter Subassembly MX-1636/U (Time Interval Unit)

of the unknown frequency. This arrangement is useful when measuring shorter periods so that higher accuracy can be obtained in the measurement.

1-26. Time intervals are measured by an arrangement similar to period measurements, except that suitable circuitry is included in the instrument so that the voltage threshold and slope for the measurements can be selected.

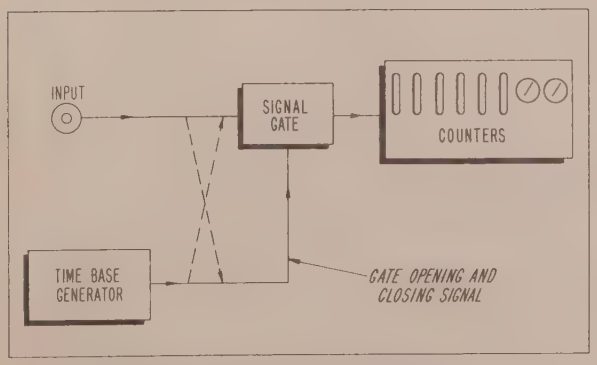


Figure 1-5. Basic Circuit Diagram, Frequency Meter FR-38/U

1-27. MEASUREMENT DISPLAY SYSTEM.

1-28. When a measurement has been made, the answer is automatically displayed in digital form across the front panel on the display system shown in Figure 1-6. The "units" digit and the "tens" digit are indicated by two adjacent meters on the right-hand side of the panel; the remaining six places, 100 through 10,000,000 digits, are indicated by illuminated numerals in the six columns to the left of the meters. For example, for the reading shown in Figure 1-6, the measured value would be 9,257.437 kilocycles if frequency were being measured.

1-29. As a part of the display system, an illuminated decimal point is automatically located for each type of measurement, regardless of the gate time being used or standard frequency counted. This decimal point minimizes the possibility of an incorrect interpretation of the displayed value.

1-30. When a measurement has been made, the answer remains displayed for a time chosen by the operator. This display time may be adjusted from 0.3 seconds to 5 seconds or to continuous display (infinite time) by a display time control on the front panel.

Table 1-3. Specifications for FREQUENCY METER AN/USM-26

FREQUENCY MEASUREMENT	
Range:	10 cps to 100 Mc (direct reading).
Accuracy:	±1 count ±0.0002%* (±0.1 cps ±0.0002% on 10-second gate).
Input Requirements:	0.2 v rms to 10 Mc; 0.02 v rms 10 Mc to 100 Mc. 1 v rms using Time Interval Unit.
Input Impedance:	0 - 10 Mc: approx. 1 megohm shunted by 40 µµf; 10 - 100 Mc: approx. 50 ohms.
Gate Time:	.001, .01, 0.1, 1, or 10 sec.; selected by panel control.
Display Time:	Continuously variable from 0.3 to 5 seconds by a panel control. In manual operation, display continues until reset.
PERIOD MEASUREMENT	
Range:	0.01 cps to 10 kc (100 µsec).
Accuracy:	±0.03%
Input Requirements:	1 v rms, minimum; 200 v rms, maximum.
Input Impedance:	Approximately 1 megohm shunted by 40 µµf.
Gate Time:	Counts for 1 or 10 cycles of input signal as desired.
Units of Measurement:	0.1 µsec, 0.01 millisecond, 1 millisecond, or 0.1 second.
Display Time:	Same as for Frequency Measurement.
TIME INTERVAL MEASUREMENT	
Range:	1.0 microsecond to 10,000,000 seconds.
Accuracy:	±0.1 microsecond ±0.0002%*.
Input Requirements:	2 v peak minimum; 200 v peak maximum.
Input Impedance:	Approx. 1 megohm shunted by 20 - 40 µµf (each channel).
Independent Start and Stop Channels:	Triggers from either positive-going or negative-going input voltages at levels from -200 to +200 volts. Separate or common direct-coupled inputs.
Display Time:	Same as for Frequency Measurement.

*Internal Standard

The accuracy figure of 0.0002% is due to the internal crystal oscillator, which has a long time stability of within two parts/million/week. Short time stability is within one part/million. A panel connector permits use of an external 100 kc primary standard signal to obtain higher accuracy.

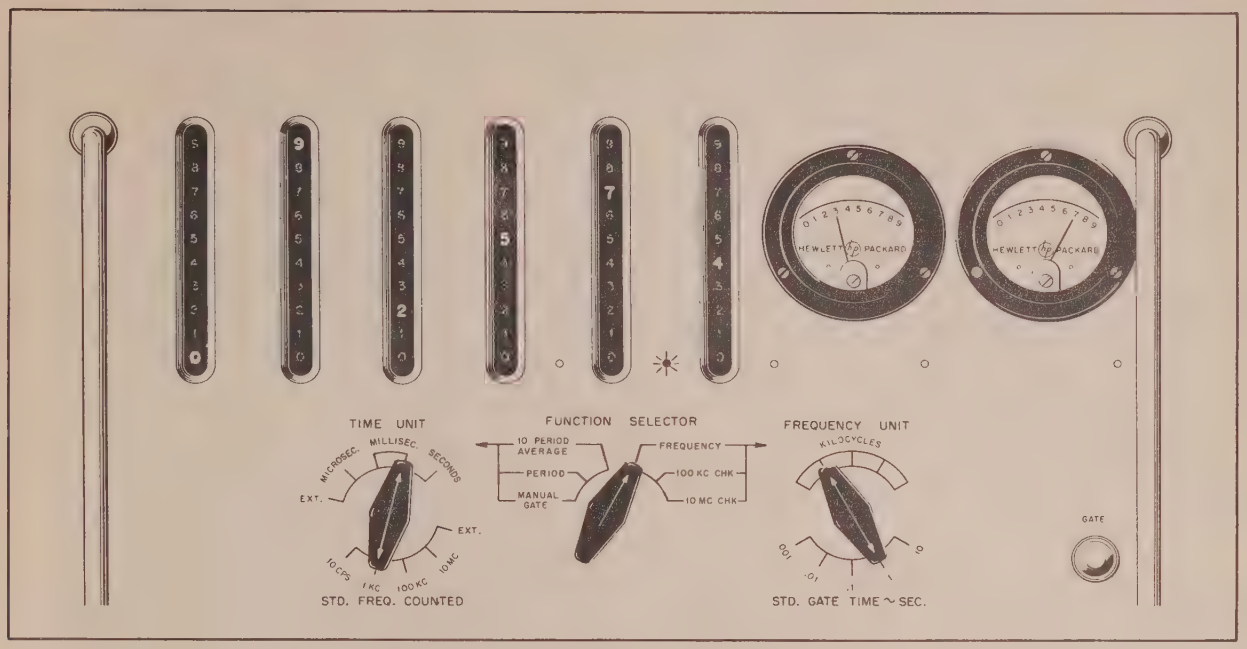


Figure 1-6. Measurement Display System

When repetitive measurements are made (the usual condition with frequency measurement), a new answer is automatically obtained and displayed when the selected display time of a previous answer is ended. If a single measurement is made (a typical case in time interval measurement), the answer to the measurement can remain displayed indefinitely or until the next measurement is made.

1-31. GENERAL DESCRIPTION.

1-32. Physically, Frequency Meter FR-38/U with one plug-in unit weighs approximately 114 pounds and is constructed for mounting in a standard 19-inch wide relay rack. The instrument is enclosed in an aluminum cabinet. The physical dimensions and mounting information for the units are shown in Figure 1-7. Both the cabinet and the front panel are finished in a light, non-reflecting gray paint. Guard-rail type handles are provided to assist in handling and to protect the front panel controls.

1-33. The time base generator in the equipment includes a crystal-controlled, 100-kc, precision oscillator whose crystal is housed in a thermostatically-controlled oven. The oven temperature is indicated by a dial-type thermometer which is visible at the front panel. As long as the equipment is connected to a power source, the crystal temperature is controlled regardless of whether the power switch on the panel is turned on or off. When the power switch is off and the instrument remains connected to a power source, a white pilot lamp on the panel indicates that power is applied to the instrument. In addition, when the white pilot lamp is on, space heaters within the cabinet are energized to maintain the internal cabinet temperature a few degrees above the ambient temperature in order to minimize moisture condensation within the cabinet. When the power switch is turned on and the measuring circuits are energized, a red pilot lamp on the panel lights and the white lamp is turned off.

1-34. Forced ventilation for the cabinet is provided by a blower at the rear of the cabinet. The air drawn into the cabinet is filtered by a renewable air cleaner.

1-35. To reduce leakage of high frequency signals generated within the frequency meter, a metal gasket is placed in a milled slot in the front panel around the opening which receives the front panel plug-in unit. The frequency meter also contains electrical noise filters to prevent noise from being conducted out of the instrument through the power cord.

1-36. Bar type knobs are used on selector switches to enhance ease of operation.

1-37. Tube replacement in many cases is possible from the front panel without removing the instrument from the cabinet or rack in which it is mounted. Removal of the front panel plug-in unit gives access to all electron tubes within the instrument with the exception of those in the counting units behind the slots in the front panel.

1-38. All input jacks are of the BNC type with protective caps and are located on the front panel. All fuses for the equipment are replaceable from the front panel and spare fuses are contained in two spare fuseholders also located on the front panel. Ten spare crystal diodes are located inside the Frequency Meter chassis, mounted on a clip-in type mounting board.

1-39. TRANSIT CASES.

1-40. Transit Cases CY-1424/USM-26 and CY-1563/USM-26 are provided with Frequency Meter FR-38/U and are shown in Figure 1-8. These cases are designed to be water-tight and contain space and mounting provisions for the accessories and handbooks

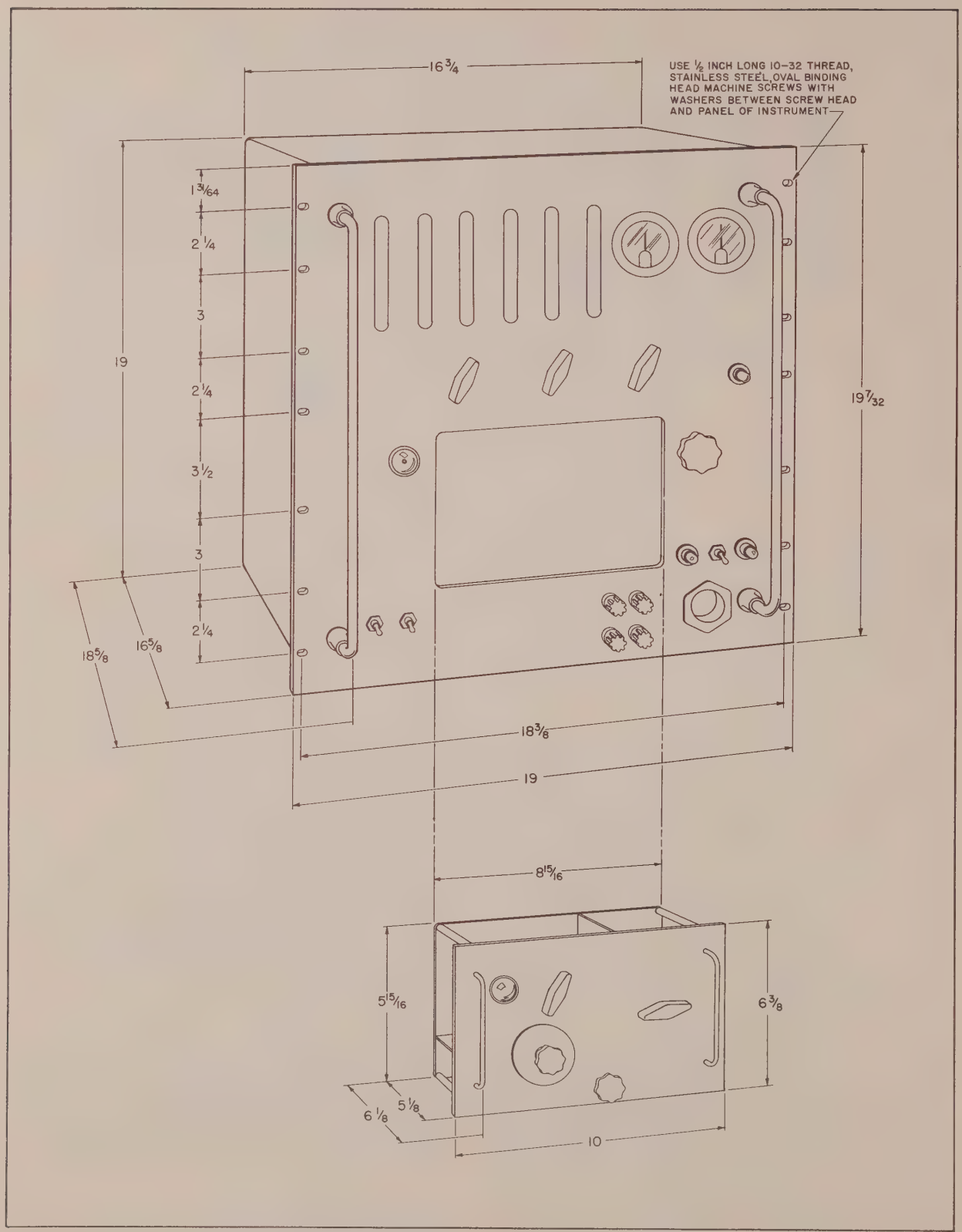


Figure 1-7. Dimensions of Frequency Meter FR-38/U and Plug-in Unit

which are supplied with the instrument (see Figure 1-9). Figure 1-10 shows the adapters as they are stowed in a tray in the main transit case.

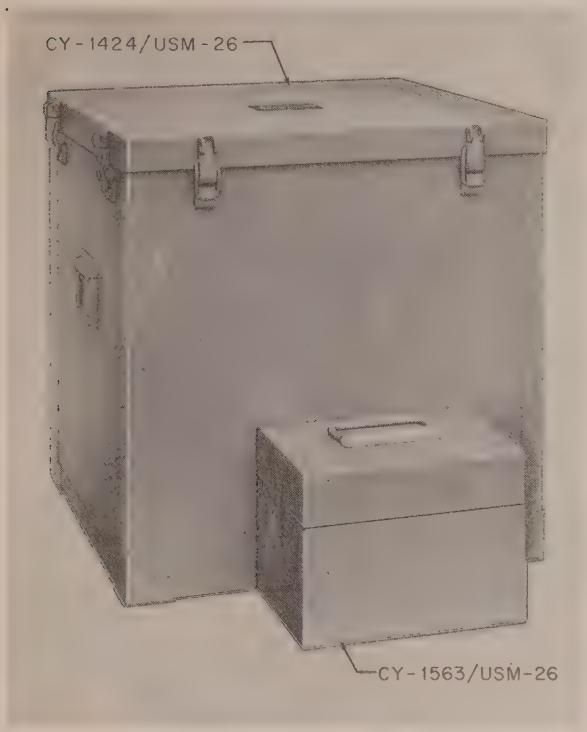


Figure 1-8. Transit Cases CY-1424/USM-26 and CY-1563/USM-26

1-41. The transit case is constructed of a special laminated material consisting of wood covered on each side with aluminum sheeting. The cover for the transit case is provided with a double lip which is filled with sponge rubber. The double lip effects a watertight seal when the cover for the case is closed. The cover is attached to the case by eight trunk-type latches.

1-42. ACCESSORIES.

1-43. The purpose of the various accessories provided with the equipment is described below.

a. Cord CG-530/U (4'0") is the signal input cable and consists of approximately four feet of RG-62/U cable with a UG-260/U plug on each end. Two such cords are supplied with the instrument.

b. Cord CX-337/U (6'0") is provided for connecting the power plug on the instrument to the a-c supply. The cord consists of approximately six feet of two-conductor cable with a conventional power plug on one end and a motor body on the opposite end.

c. Cord CX-2927/USM-26 is a special purpose test cable, 13-1/2 inches long, with special 16-connector Amphenol type plugs on each end. The cable provides electrical connection for either plug-in unit when it is physically removed from the main instrument for test and adjustments.

d. Cord CX-2928/USM-26 is a special purpose test cable, 13-1/2 inches long, with special 8-connector Amphenol type plugs on each end. The cable provides electrical connection for either plug-in unit when it is physically removed from the main instrument for test and adjustments.

e. Adapter UG-201A/U is provided for adapting a type N male connector to a type BNC female connector. Two such adapters are provided with each instrument.

f. Adapter UG-255/U is provided for adapting a UHF female connector to a type BNC male connector. Two such adapters are provided with each instrument.

g. Adapter UG-273/U is provided for adapting a UHF male connector to a type BNC female connector. Two such adapters are provided with each instrument.

h. Adapter UG-282/U is provided for adapting the type BNC male connector to a common binding post. Two such adapters are provided with each instrument.

i. Adapter UG-349A/U is provided for adapting a type N female connector to a type BNC male connector. Two such adapters are provided with each instrument.

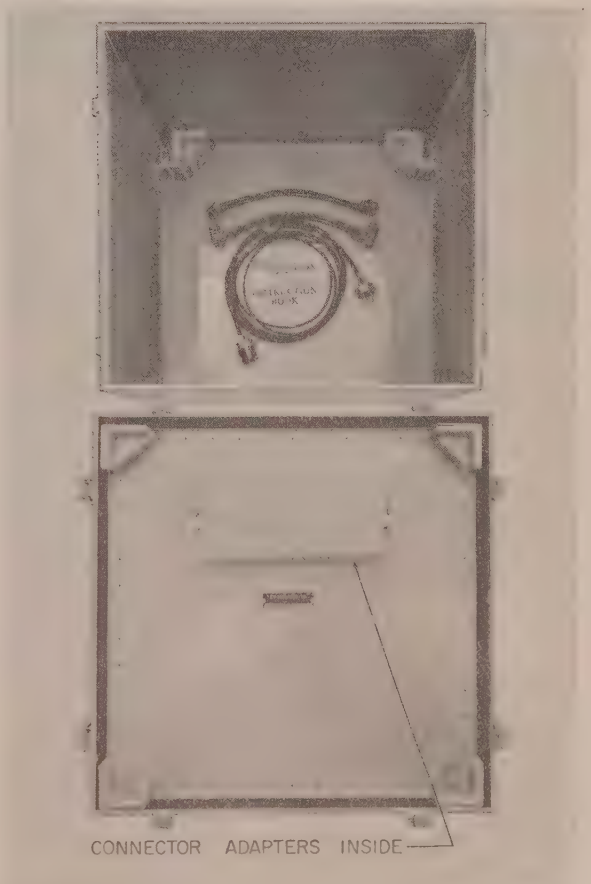


Figure 1-9. Cable and Accessory Storage in Transit Case CY-1424/USM-26

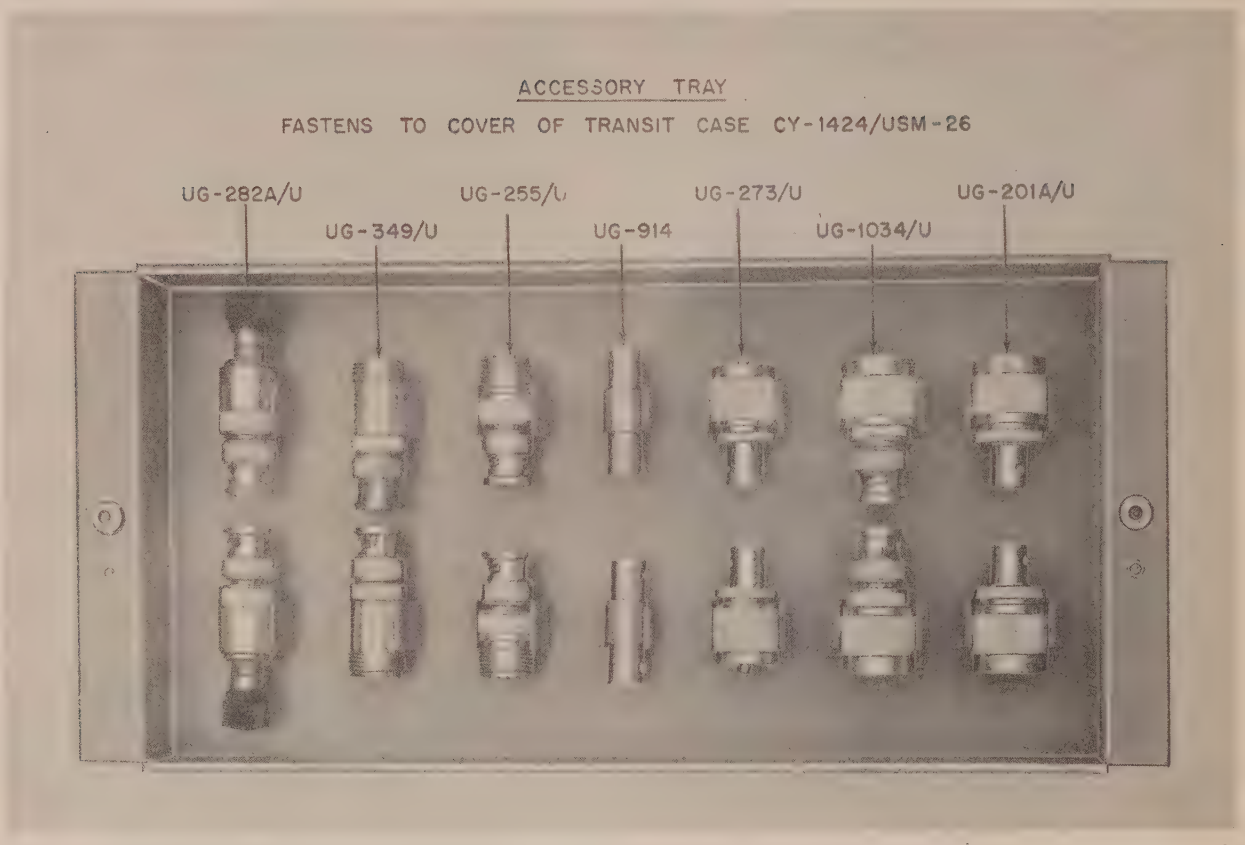


Figure 1-10. Accessory Tray Showing Connector Adapters

j. Adapter UG-914/U is a type BNC double female connector provided for connecting two BNC type male connectors together. Two such adapters are provided with each instrument.

k. Adapter CG-1034/U is provided for adapting a type N male connector to a type BNC male connector. Two such adapters are provided with each instrument.

1-44. QUANTITY AND TYPES OF TUBES AND LAMPS.

1-45. The vacuum tubes and lamps used in Frequency Meter FR-38/U are listed in Table 1-4 together with the quantities used of each.

Table 1-4. Tubes and Indicator Lamps

JAN or NAVY TYPE	QUANTITY	JAN or NAVY TYPE	QUANTITY
OB2WA	1	5725/6AS6W	9
5Y3WGTA	1	5727/2D21W	2
5R4WGA	3	5726/6AL5W	3
6AH6	11	5844	1
6AU6WA	7	5963	40
6CB6	5	6005/6AQ5W	2
6E5	1	6080WA	2
12AT7WA	3	Mazda 47 (lamp)	8
5654/6AK5W	6	G-11A Crystal diodes	63
5687	1	Spare G-11A Crystal diodes	10

SECTION II

INSTALLATION AND OPERATION

2-1. FUNCTION OF EQUIPMENT.

2-2. Frequency Meter FR-38/U with its two panel plug-in units is a precision instrument that automatically measures frequencies up to 100 megacycles and presents the value of the measured frequency on a direct-reading digital indicating system. In addition to measuring frequency, the instrument also measures period (1/f), time intervals, frequency ratios, and the total number of electrical events that occur during the course of a measurement. The equipment will also "self-check" its own circuits for proper operation. The capabilities of the instrument in making these measurements are summarized in Table 1-3 of Section I.

2-3. INSTALLATION.

2-4. The FR-38/U equipment is designed primarily for mounting in a relay rack, although it may also be used on a test bench. The following information assumes, however, that the instrument will be rack-mounted.

2-5. After unpacking the equipment, remove it from its transit cases. Install the main component in a relay rack, referring to Figure 1-7 for necessary mounting dimensions. Assuming that the rack is tapped for #10-24 machine screws, install the equipment using fourteen #10-24 by 1/2-inch screws. Oval head binder screws with large flat washers are recommended. The mounting arrangement should assure a free intake of air for the fan at the back of the cabinet as well as adequate circulation of air around the cabinet.

2-6. The FR-38/U has provisions whereby an external frequency standard can be used in place of the 100 kc internal precision crystal oscillator. Information pertaining to the use of the external frequency standard is found in paragraph 3-10.

2-7. A space convenient to the equipment for stowing one of the panel plug-in units is also desirable.

2-8. POWER CONNECTION. The equipment operates from a nominal 115-volt, 50-1000 cps single phase power source. The power connector is located on the front panel. A six-foot power cord is provided. It is highly desirable that the power source is not subject to interruption, since the equipment contains a quartz crystal in a temperature-regulated oven. The oven circuit is always energized as long as the equipment is connected to a power source.

2-9. Turn off POWER switch on equipment and install either of the plug-in units in the large opening in the panel.

CAUTION

The POWER switch on the instrument must be turned off (in "down" position) before installing or removing a front panel plug-in unit. Failure to do so may cause voltage arcing as the pins of the 8- and 16-contact plug-in connectors engage or disengage.

2-10. TURNING ON THE EQUIPMENT. After the equipment has been installed and connected to a power source, turn the POWER switch on and allow equipment to warm up for 15 minutes or longer.

CAUTION

During the first warm-up period, keep a close watch on the crystal oven thermometer on the front panel to be sure of proper operation. It will normally require about one-half hour for the oven to reach its operating temperature of 65° ±5°C (149° ±9°F) and about two hours for the crystal itself to be heated thoroughly. If thermometer overshoots its reading, DISCONNECT EQUIPMENT FROM POWER SOURCE and investigate source of trouble.

2-11. TURNING OFF THE EQUIPMENT. During periods when the equipment is not in use, it can be turned off by setting the POWER switch to the standby or down position. When the POWER switch is in the standby position, the crystal oven heater circuits are energized so that the crystal temperature is regulated. DO NOT disconnect the equipment from its power source.

2-12. OPERATING CONTROLS, DIALS, AND TERMINALS.

2-13. Table 2-1 summarizes the functions of each of the operating controls, dials, and terminals of the FR-38/U equipment. The numbers shown in the table correspond to the numbers assigned to the panel controls in Figure 2-1. The functions of each of the controls are further discussed in this section as part of the operating information.

2-14. THE SELF-CHECK FEATURE.

2-15. GENERAL. By means of the self-check feature, the operator can in one simple procedure check out for satisfactory operation those circuits that are used in the various measurement functions performed by the instrument. These circuits include those used when measuring frequencies below 10 megacycles, measuring period, totalizing, or measuring frequency

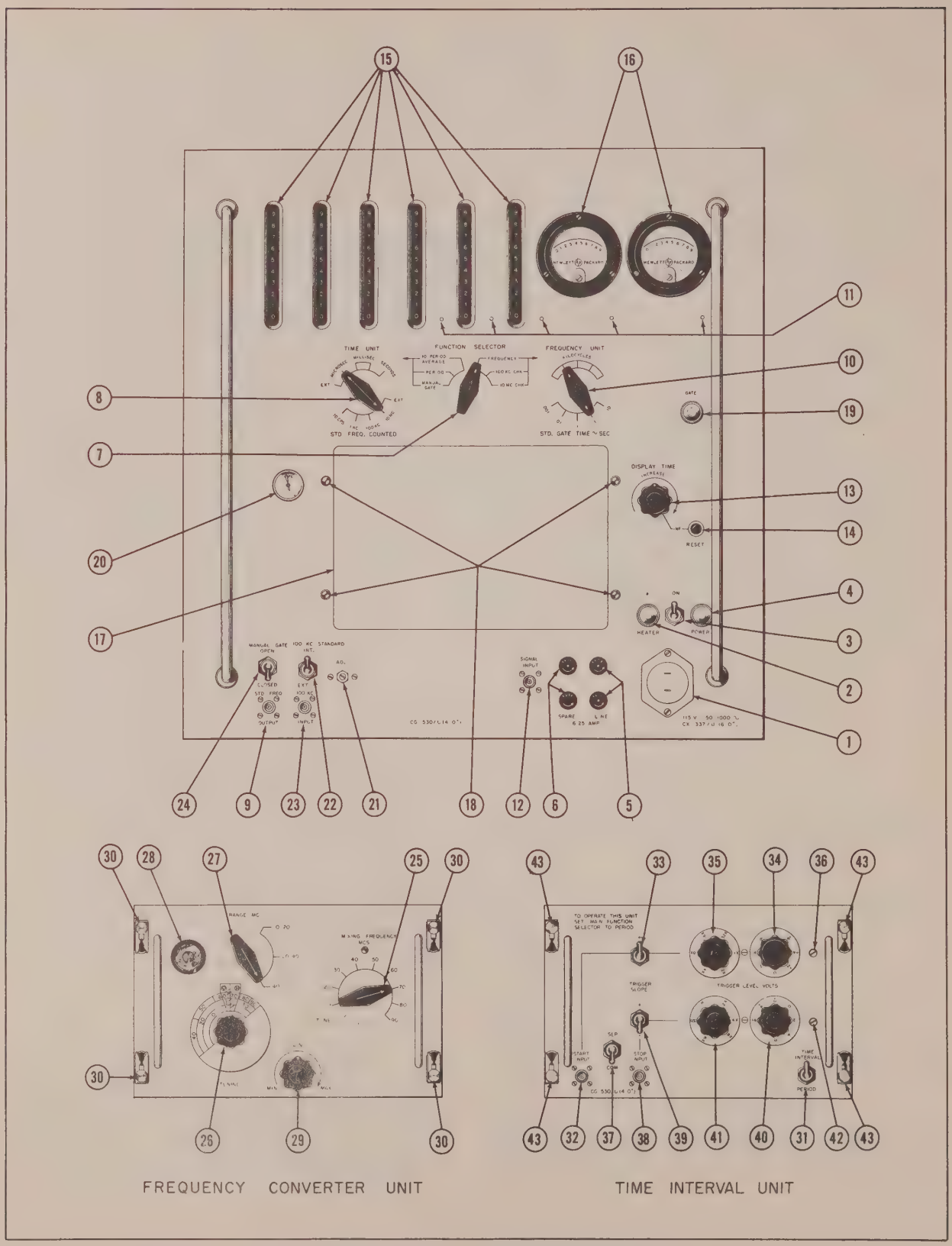


Figure 2-1. Frequency Meter FR-38/U and Plug-in Units, Controls Numbered

ratios and those circuits, excluding the Time Interval Unit, that are used for time interval measurement. This includes essentially all circuits in the main cabinet of the equipment. The self-check feature, however, does not check the operation of the panel plug-in units, nor does it give an indication of the accuracy of the internal 100 kc precision crystal oscillator. To check the operation of the plug-in units, it is necessary to make a frequency measurement and a time interval measurement as described in paragraphs 2-21 and 2-69. Adjusting the frequency of the 100 kc oscillator is described in paragraph 3-4.

Table 2-1. Panel Controls and Connectors

Ref. No. Fig. 2-1 -	Designation	Function
1	115v 50-1000 CX-337/U (6'0")	AC Power Input Connector.
2	HEATER	White pilot lamp that indicates when crystal heater and space heater are energized. Lighted at all times if power is supplied to (1), except when red pilot lamp (4) is lighted.
3	ON	Power switch. "ON": All circuits energized. Opposite position: Only crystal heater and space heater energized.
4	POWER	Red pilot light that indicates when all circuits are energized.
5	LINE	Fuse holders - one for each side of line.
6	SPARE	Holders for spare fuses.
7	FUNCTION SELECTOR	Master control that prepares instrument for type of measurement to be made.
8	TIME UNIT	Selects standard frequency to be counted for 10 Period Average, Period, Manual Gate, and Time Interval operation.
9	STD. FREQ. OUTPUT	Type BNC jack at which is available standard frequency pulse output as selected by "Time Unit" (8) switch. 1 volt peak is available into 1000 ohm load. When Time Unit (8) switch is in EXT position, external frequency to be counted should be connected to this terminal.
10	FREQUENCY UNIT	Selects standard gate time for all frequency measurements and self-check positions.
11	- - - -	Illuminated decimal points.
12	SIGNAL INPUT	Type BNC jack which receives signal frequency to be measured for all measurements except time interval and totalizing.
13	DISPLAY TIME	Control that regulates display time.
14	RESET	Manual reset for starting new count when Display Time (13) set to "INF" position. Returns counters to zero in "MANUAL GATE" operation
15	- - - -	Illuminated columns of numbers that indicate first six digits of display.
16	- - - -	Meters that indicate last two digits of display.
17	- - - -	Aperture for panel Plug-in Units.

Table 2-1. Panel Controls and Connectors (Cont.)

Ref. No. Fig. 2-1	Designation	Function
18	- - - -	Panel Plug-in Unit retaining studs.
19	GATE	Neon lamp that lights when gate is open (not used for operating purposes).
20	- - - -	Crystal oven temperature indicator. Correct oven temperature is 65° ±5°C (149° ±9°F).
21	ADJ	Screwdriver operated trimmer capacitor that adjusts internal 100 kc standard frequency. (Not an ordinary operating adjustment.)
22	100 KC STANDARD INT EXT	Switch that arranges instrument to operate using internal 100 kc standard oscillator or using external 100 kc standard frequency.
23	100 KC INPUT	Type BNC jack that receives external 100 kc standard frequency. 1 volt peak minimum into approx. 1 megohm is required.
24	MANUAL GATE OPEN	Switch that opens and closes gate when Function Selector (7) is set to "MANUAL GATE".
The following controls are located on the Frequency Converter Plug-in Unit.		
25	MIXING FREQUENCY MCS	Switch that selects mixing frequency.
26	TUNING	Tuning dial for preselector.
27	RANGE - MC	Range selector switch for TUNING dial (26).
28	- - - -	Preselector tuning indicator "eye" when MIXING FREQUENCY (25) switch is in TUNE position; indicates output level of Converter plug-in unit for all other positions of switch.
29	GAIN	Control that adjusts gain of amplifier in Converter unit so that proper output level is obtained.
30	- - - -	Snap-slide fasteners for securing plug-in unit. Connects with retaining studs (18).
The following controls are located on the Time Interval Plug-in Unit.		
31	TIME INTERVAL PERIOD	Switch that permits time interval or period measurements to be made when T-I unit is plugged in and FUNCTION SELECTOR (7) is set to PERIOD.
32	START INPUT	Type BNC jack that accepts start signals of either polarity and up to 200 volts peak amplitude.
33	TRIGGER SLOPE	Switch that sets start channel to trigger on either positive- or negative-going signals.
34	TRIGGER LEVEL VOLTS	Control that adjusts start channel (in combination with control 35) to trigger at any point between -200 and +200 volts peak.
35	TRIGGER LEVEL VOLTS	Multiplier for control (34).
36	- - - -	Screwdriver-operated calibration adjustment for start trigger level control (34). (Not an ordinary operating control.)

Table 2-1. Panel Controls and Connectors (Cont.)

Ref. No. Fig. 2-1	Designation	Function
37	SEP COM	Separates or connects start and stop input connectors (32 and 38).
38	STOP INPUT	Type BNC jack that accepts stop signals of either polarity and up to 200 volts peak amplitude.
39	TRIGGER SLOPE	Switch that sets stop channel to trigger on either positive- or negative-going signals.
40.	TRIGGER LEVEL VOLTS	Control that adjusts stop channel (in combination with control 41) to trigger at any point between -200 and +200 volts peak.
41	TRIGGER LEVEL VOLTS	Multiplier for control (40).
42	- - - -	Screwdriver operated calibration adjustment for stop trigger level control (40). (Not an ordinary operating control.)
43	- - - -	Snap-slide fasteners for securing plug-in units. Connects with retaining studs (18).

2-16. It is necessary that one of the panel plug-in units be in place to self-check the instrument. However, none of the controls on the plug-in units are used. It is not necessary that any cables that connect the instrument to an external frequency source be disconnected.

2-17. WHAT THE SELF-CHECK DOES. For the purpose of considering the self-check feature, the circuit of the FR-38/U can be represented by the simplified diagram shown in Figure 2-2. The time base generator supplies two frequencies, 100 kc and 10 mc, which are derived from the precision 100 kc oscillator. This oscillator is part of the time base generator. Either of these frequencies can be passed through the gate circuits to the counters. At the same time, any of the five gate times that the instrument provides can be used.

2-18. Since the values of the two self-check frequencies are known, the accuracy of the reading on the counters for any of the five gate times can be established. By noting the readings obtained when these frequencies are measured, it is possible to determine that the equipment is operating properly.

2-19. The self-check feature can also be used when a 100 kc frequency from an external standard is being used in place of the internal oscillator. In this case, the equipment will derive the two self-check frequencies from the external frequency.

2-20. STEP-BY-STEP PROCEDURE FOR SELF-CHECKING FREQUENCY METER FR-38/U.

a. If an external 100 kc frequency is being used in place of the 100 kc frequency generated by the internal precision oscillator as described in paragraph 3-10, the self-check feature will check out the equipment in terms of this external frequency. Therefore, the connection between the equipment and the external standard should be allowed to remain.

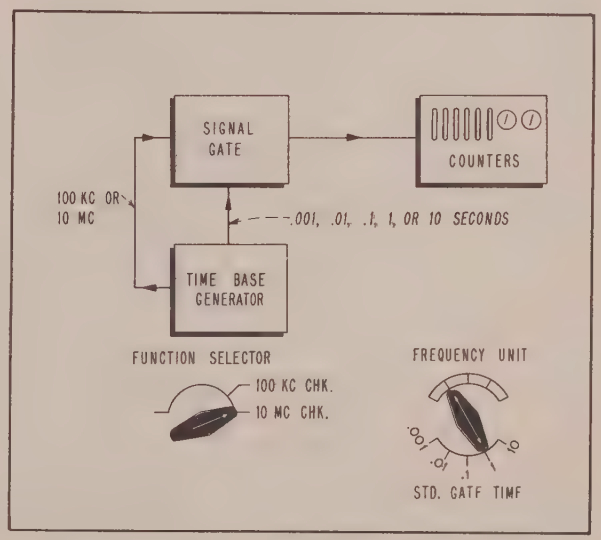


Figure 2-2. Self-Check, Circuit Block Diagram

b. One of the two panel plug-in units must be in place. Turn power switch (3) off before removing or installing a panel plug-in unit.

c. Turn on power switch (3) and allow equipment to

heat for at least 5 minutes. A longer warm-up should be allowed if ambient temperature is below normal room temperature.

d. Set MANUAL GATE (24) switch to closed position.

e. Set FUNCTION SELECTOR (7) to 100 KC CHECK position.

f. Adjust DISPLAY TIME (13) control for desired display. The extreme counterclockwise position is usually best. (Display time cannot be adjusted to be less than gate time.)

g. Note readings obtained on display system for each position of FREQUENCY UNIT (10) switch. These readings should agree with values in Table 2-2. If readings do not agree with the table after equipment has had an adequate warm-up period, the phantastron circuits should be checked.

h. Now set FUNCTION SELECTOR (7) to 10 MC CHECK position.

i. Repeat step g. However, when checking 10 mc, note that a discrepancy of ±1 count in the last digit is acceptable because of tolerances in the operation of the gate circuits.

j. If the correct readings are obtained, the equipment can be considered to be operating properly. If the readings are incorrect, the instrument should be referred to proper service personnel for repair.

Table 2-2. Counter Readings for Self-Check Operations

GATE TIME	100 KC CHECK	10 MC CHECK
10 sec	0100.0000	0000.0000 ± .0001
1 sec	00100.000	10000.000 ± .001
0.1 sec	000100.00	010000.00 ± .01
0.01 sec	0000100.0	0010000.0 ± .1
0.001 sec	00000100.	00010000. ±1

2-21. FREQUENCY MEASUREMENT.

2-22. When the AN/USM-26 is being used to measure frequency, its circuit arrangement is as indicated by the block diagrams of Figures 2-3 and 2-4. If the frequency to be measured is known to be less than 10 megacycles, the Frequency Converter Unit does not necessarily need to be used, although it is necessary that one of the panel plug-in units be in place. Use of the Converter unit when measuring frequencies below 10 megacycles will, however, increase the sensitivity of the instrument from 1 volt rms to 0.2 volt rms.

2-23. Frequencies higher than 10 megacycles are applied to the Converter where their approximate frequency is measured by a preselector. The preselector,

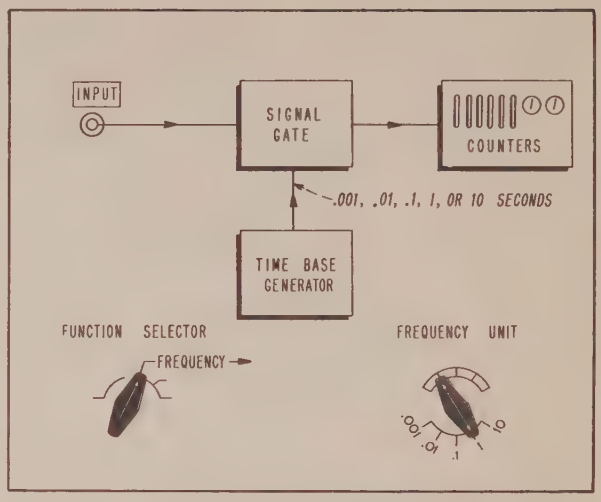


Figure 2-3. Frequency Measurement Below 10 Mc, Circuit Block Diagram

instead of being calibrated to indicate directly the frequency be measured, is calibrated to indicate the mixing frequency that should be selected for the frequency under measurement. When the proper mixing frequency has been selected, the output of the converter will be a frequency not higher than 10.1 megacycles. For example, if a frequency of 44 megacycles is to be measured, the preselector will indicate that a mixing frequency of 40 megacycles should be selected. When this mixing frequency is selected by the control on the Converter panel, the output from the Converter will be the difference frequency of 4 megacycles. This difference frequency will be applied to the signal gate and subsequently measured by the counter circuits.

2-24. To insure its proper use, the Converter unit has a "tuning eye" tube that indicates preselector tun-

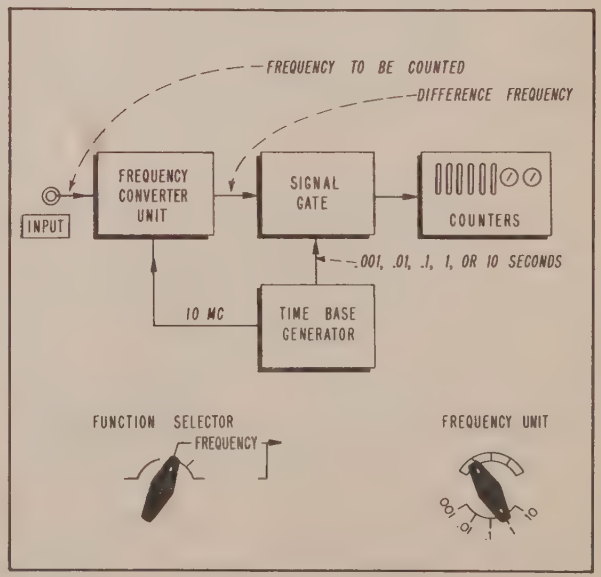


Figure 2-4. Frequency Measurement Above 10 Mc, Circuit Block Diagram

ing as well as the output level of the difference frequency produced by the Converter.

2-25. If the frequency to be measured is less than 10 megacycles, it is not converted. In such a case, it is amplified by the video amplifier in the Converter unit and applied to the signal gate and counters for direct measurement.

2-26. CONTROLS AND TERMINALS USED IN FREQUENCY MEASUREMENTS. (See Figure 2-1.)

2-27. The FUNCTION SELECTOR (7) is the master control and must be set to FREQUENCY for any frequency measurement.

2-28. The FREQUENCY UNIT (10) switch selects the length of time that the gate will be open and thus the length of time that the input frequency will be counted. Five of these standard gate times are available: 10 seconds, 1 second, 0.1 second, 0.01 second, and 0.001 second. Greatest accuracy is obtained using the 10-second gate time. The shorter gate times offer a continuous display of the measured frequency when minimum display time is used. They are thus useful for making rough tuning adjustments on external equipment when measurement accuracy is secondary to the convenience of continuous display. The FREQUENCY UNIT switch also locates the illuminated decimal point.

2-29. The automatic display time is adjustable from at least 0.3 to 5 seconds (DISPLAY TIME 13) except that the display time cannot be adjusted to be less than the gate time used. A longer display time may be obtained by setting the display time control to INF. In this position a count will be displayed until the RESET button (14) is pressed. This resets the counter to zero and allows a new count to be started.

2-30. The SIGNAL INPUT connector (12) is provided to receive the frequency to be measured, both when the Frequency Converter Unit is used and when it is not used. In the range below 10 mc, the input impedance at this connector is approximately 1 megohm shunted by 40 μμf. In the range above 10 mc, the input impedance is approximately 50 ohms. Below 10 mc, a minimum input voltage of 0.2 volt rms is required if the Frequency Converter Unit is in place. If the Time Interval Unit is used when measuring frequencies below 10 mc, a minimum input voltage of 1 volt rms is required. Above 10 mc, where use of the Frequency Converter is required, a minimum input voltage of at least 0.02 volt rms is necessary. Maximum permissible noise in the input signal is 2 millivolts when the Converter is in place or 10 millivolts when the Time Interval Unit is in place. An unstable reading on the counters is an indication of excessive noise or insufficient signal.

2-31. The 100 KC INPUT connector (23) is provided to receive a standard frequency from an external frequency standard whose accuracy exceeds that of the internal standard. Details of this arrangement are described in paragraph 3-11.

2-32. The STD. FREQ. OUTPUT connector (9) provides any one of the four frequencies indicated by the TIME UNIT switch (8). Any one of these frequencies is available for external use when any type of frequency measurement is being made. The output waveform from the connector is a pulsed waveform except for a nominal sinusoidal waveform for the 10 mc frequency. At least 1 volt peak is available into a load impedance of 1000 ohms.

2-33. The Frequency Converter panel plug-in unit extends the frequency measurement range of the FR-38/U from 10 to 100 megacycles. From an operating viewpoint, the Converter does two things. It indicates the approximate value of the frequency to be measured, and it converts this frequency to a difference frequency that is always below 10.1 megacycles and can thus be measured by the main part of the equipment.

2-34. When the MIXING FREQUENCY (25) switch is in the TUNE position, the plug-in unit is prepared to measure the approximate value of the unknown frequency. The TUNING dial (26) has three arcs of calibration which correspond to the three positions of the RANGE - MC switch (27). When the TUNING dial is tuned to the frequency of the unknown, the tuning eye (28) will close or partially close.

2-35. The TUNING dial (26) is not calibrated in terms of the frequency of the unknown; rather, it is calibrated in terms of the mixing frequency that should be used for the measurement. When an indication is obtained on the tuning eye, then the TUNING dial shows the frequency to which the MIXING FREQUENCY control (25) should be set. For example, if an unknown frequency of, say, 55 megacycles were being measured, an indication should be obtained on the tuning eye when the TUNING dial was approximately at the middle of its "50" region and the RANGE - MC switch in the 40 - 100 position. The reading of the TUNING dial thus indicates that the MIXING FREQUENCY control should be set to its "50" position for the measurement.

2-36. When the MIXING FREQUENCY control is set to any of its positions other than TUNE, the tuning eye changes from a tuning indicator to an indicator of the voltage level of the video output frequency of the Converter. To continue with the above example, then, when the MIXING FREQUENCY control was set to "50", the tuning eye would at least partially close. In order for the difference frequency to be at the proper level to be measured, the GAIN control (29) should be adjusted so that the tuning eye is approximately closed but does not overlap.

2-37. The reading obtained on the display system, combined with the setting of the MIXING FREQUENCY switch, indicates the value of the frequency being measured. In the above example, a reading of 5,000.000 kilocycles would have been obtained on the display system. Since the MIXING FREQUENCY switch was in the 50 megacycle position, the value of the frequency being measured is 55 megacycles.

2-38. FREQUENCY MEASUREMENT TECHNIQUE. In any heterodyne system in which the mixing frequency is close to the heterodyned frequency, there is possibility for ambiguity. Thus, when measuring

a frequency of, say, 49.98 megacycles, the preselector will indicate that the frequency is approximately 50 megacycles; and a reading on the counter of 0.02 megacycles will be obtained. The question is whether this reading should be subtracted or added to the 50-megacycle mixing frequency.

2-39. This example demonstrates that it has been necessary to design the equipment so that the mixing frequency will not be worked close to the frequency being measured. For this reason, the preselector tuning control has been calibrated in such a way that the mixing frequency will not be selected to be within 100 kc of the unknown. Thus, the dividing points on the TUNING dial correspond to unknown frequencies of 10.1, 20.1, 30.1, etc., megacycles. As a result, the counter readings will always lie between 100 kc and 10.1 megacycles.

2-40. This arrangement calls for a special technique when measuring a frequency that lies on or very near the dividing lines on the TUNING dial. In such cases, the MIXING FREQUENCY switch should always be set first to the lower of the two possible mixing frequencies. If a frequency of 70.05 megacycles were to be measured, for example, the TUNING dial would point to the division mark between 60 and 70. In such a case the MIXING FREQUENCY switch should be set first to 60 megacycles so that a counter reading of 10.05 megacycles would be obtained. The measurement can then be double-checked by setting the MIXING FREQUENCY switch to 70 megacycles so that a counter reading of 0.05 megacycles will be obtained. In this particular example, a triple-check could be made by setting the MIXING FREQUENCY switch to 80 megacycles, in which case a reading of 9.95 megacycles would occur. Subtracted from 80 megacycles, this again gives the value of the unknown as 70.05 megacycles.

2-41. Since the counter circuits directly count frequencies as high as 10 megacycles, preselection and mixing are not necessary for frequencies below 10 megacycles. Frequencies in this range will be amplified if the Converter unit is in place and passed directly through the gate to the counters.

2-42. The GAIN control of the Frequency Converter Unit is effective when the MIXING FREQUENCY switch is in the 0 position (i.e., when measuring frequencies below 10.1 megacycles). This is often of value when measuring frequencies that have a low signal-to-noise ratio.

2-43. When measuring frequencies below 10.1 megacycles with the Frequency Converter in place, the GAIN control should be adjusted so that the tuning eye just closes. When this is done with a signal that has a poor signal-to-noise ratio, it may be found that the reading on the display system is erratic or erroneous, because some of the noise frequencies are being measured along with the desired signal. In such a case, the setting of the GAIN control can be reduced in slight steps until a stable, accurate reading is obtained. The final reading should be stable over a significant range of GAIN settings before the readings can be considered to be unaffected by noise. This procedure is usually useful with signal-to-noise ratios as low as 20 db.

2-44. ACCURACY OF FREQUENCY MEASUREMENT (USING THE FREQUENCY CONVERTER UNIT).

2-45. The accuracy of the Model FR-38/U is determined by an internal oscillator that is accurate within approximately 2 parts per million per week and by a possible error of ±1 count that is inherent in the gate and counter type of instrument. Accuracy at the higher frequencies is determined primarily by the oscillator, which is equal to a high-quality secondary frequency standard. At the lower frequencies, those below 10 kc, the percentage error due to the ±1 count increases rapidly. Below 316 cycles per second, greater accuracy is obtained by measuring the period of the wave that can be obtained by measuring the frequency directly. Techniques for measuring period are described later.

2-46. In counting terms, frequency measurements are accurate within 0.0002% ±0.1 cycle if the sampling time is 10 seconds (10-second standard gate time) or 0.002% ±1 cycle if the sampling time is 1 second. For shorter sampling times the accuracy will be correspondingly less. A plot of the accuracy obtained for each of the standard gate times (for the entire frequency range) is shown in Figure 2-5.

2-47. Where there is at hand a 100 kc primary standard of better accuracy than that of the internal oscillator, the accuracy of the FR-38/U can be increased by substituting the laboratory standard for the internal oscillator. A panel connector and switch are provided for this purpose. When using an external standard, the maximum accuracy of the equipment becomes the accuracy of the external standard ±1 count (±0.1 cycle on 10 sec gate).

2-48. STEP-BY-STEP PROCEDURES FOR FREQUENCY MEASUREMENT.

2-49. A summary of specifications and step-by-step operating procedures for frequency measurement are given in paragraph 2-116.

2-50. PERIOD MEASUREMENT.

2-51. Besides being arranged to measure frequency directly, the FR-38/U is also arranged so that it can measure directly the period (1/frequency) of the frequency to be measured. Period measurements become valuable when measuring low frequencies, where on direct frequency measurements the available sampling times would permit only a few cycles of the unknown to be measured. The ability to make period measurements extends the measurement range of the instrument to frequencies as low as 0.01 cps.

2-52. When set for period measurements, the time base and the signal input circuits are interchanged from their frequency measurement positions, as indicated in Figure 2-6. When the circuits are so connected, the counters count the output of the time base for the period of the unknown input signal. Thus, the standard frequencies generated in the time base are used as units of time to measure the unknown period in terms of microseconds, milliseconds, or seconds. To improve further the accuracy of the measurement,

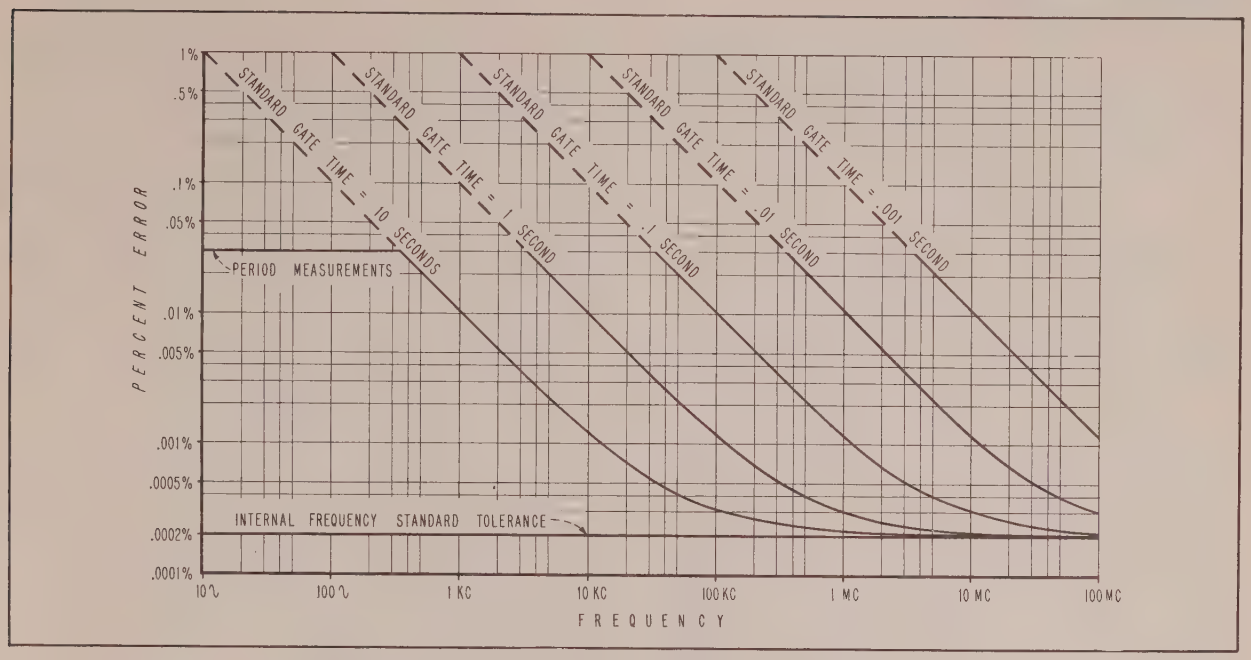


Figure 2-5. Frequency Measurement Accuracy Curves

circuits are included that shape the incoming waves so that the gate opens and closes at the same point on the measured waveform.

2-53. The FR-38/U will measure either one period or the average of 10 periods of an unknown. Ten period average measurements are more accurate and are particularly recommended for measuring the shorter periods. Switching the FR-38/U to 10 period average connects the decade divider and automatically locates the illuminated decimal point one place to the left.

2-54. CONTROLS AND TERMINALS USED IN PERIOD MEASUREMENTS. (See Figure 2-1.)

2-55. The FUNCTION SELECTOR (7) is the master control and must be set to PERIOD for period measurement or to 10 PERIOD AVERAGE for 10 period average measurement. Ten period measurement is more accurate, while single period measurement is faster.

2-56. The TIME UNIT (8) switch selects the standard frequency that will be counted and indicates the units of time in which the answer will be presented. Four internal standard frequencies are available: 10 megacycles, 100 kc, 1 kc, and 10 cps. These frequencies correspond to time units of microseconds (in units of 0.1 microsecond), milliseconds (in units of 0.01 millisecond), milliseconds (in units of 1.0 millisecond), and seconds (in units of 0.1 second). The greatest accuracy of measurement will be obtained when using the internal frequency that gives the largest number of counts on the display system.

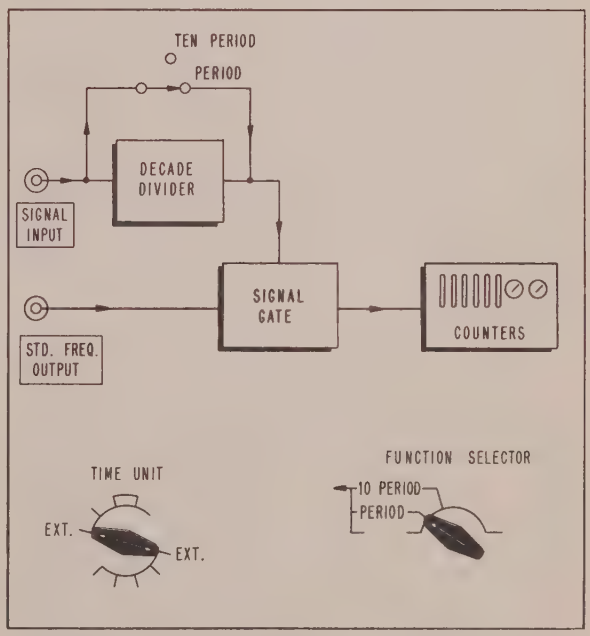


Figure 2-6. Period Measurement, Circuit Block Diagram

2-57. The EXT position of the TIME UNIT switch permits an external standard frequency to be applied to the STD. FREQ. OUTPUT connector (9) and to be counted in place of one of the internal standard fre-

quencies. The internal standard frequencies selected by the TIME UNIT switch are available for external use at the STD. FREQ. OUTPUT (9) connector. The voltages appearing at this connector have an amplitude of at least 1 volt peak into 1000 ohms.

CAUTION

The load impedance of STD. FREQ. OUTPUT connector J-205 is approximately 1000 ohms. Excessive loading resistively or capacitively (by long cable lengths) of J-205 must be avoided since it will also load the internal standard frequencies counted during Period, Time Interval, or Manual Gate operations and cause erratic count. During any operation where internal standard frequencies are counted, it may be necessary to remove cables from STD. FREQ. OUTPUT to obtain correct readings.

2-58. The automatic display time is adjustable from at least 0.3 to 5 seconds (DISPLAY TIME 13). A longer display time may be obtained by setting the display time control to INF. In this position a count will be displayed until the RESET (14) button is pressed, which resets the count to zero and allows a new count to start.

2-59. As the panel plug-in units take no active part in the period measuring functions of the FR-38/U, either unit may be used. One or the other of the plug-in units must be in place, however, in order to complete the input circuit. With one exception, the controls of the panel plug-in units are not used. The one exception is that the TIME INTERVAL - PERIOD switch (25) on the Time Interval Unit must be in the PERIOD position.

2-60. The SIGNAL INPUT (12) connector is provided to receive the signal whose period is to be measured. The input signal must not be less than 1 volt rms nor more than 200 volts rms. It may have any rise time, although maximum accuracy requires fast rise time. The input impedance is approximately one megohm shunted by 40 μμf.

2-61. PERIOD MEASUREMENT TECHNIQUE. As lower and lower frequencies are measured, the tolerance of ±1 count in gate operation becomes increasingly important on a percentage basis. Where a tolerance of one count in one hundred million is but 0.000001%, a tolerance of one count in one hundred thousand is 0.001%. Finally a point is reached where measurements can be made with greater accuracy by reversing the frequency measurement process; that is, by determining frequency through a measurement of its period. This transition for a one-volt input signal occurs at 316 cycles per second. Frequencies above 316 cycles are most accurately measured by direct frequency measurement while frequencies below 316 cps are most accurately measured by measuring their 10 period average.

2-62. Period measurements are fully automatic and little or no special operating technique is involved. The FR-38/U directly measures and directly displays the period of the unknown in the time units indicated by the setting of the TIME UNIT switch.

2-63. ACCURACY OF PERIOD MEASUREMENT. For frequencies below 316 cps, the accuracy of period measurement is largely determined by the accuracy with which triggering occurs at the same point on consecutive cycles of signal voltages having a slow rate-of-rise. Errors caused by imperfect triggering will be proportional to the change in the triggering level and inversely proportional to the slope of the negative-going input voltage (at the zero-volt level) in volts-per-microsecond. Since the maximum slope of a sine wave is proportional to both the amplitude and frequency, the error in microseconds for a given fluctuation in the triggering level is inversely proportional to both amplitude and frequency. Thus, for a constant input amplitude, the percentage error due to a given fluctuation in the triggering level will be constant. In the FR-38/U this error has been held to ±0.3% for a one-volt rms sine wave input for single period measurement and to ±0.03% when the average of 10 periods is measured. For a 10-volt rms sine wave input, this error would become ±0.03% for a single period measurement and 0.003% for a 10-period average measurement. A complete presentation of the possible error is shown in Figure 2-7 where a graph plotting the error for both period and 10-period average measurement for a one-volt rms sine wave input is shown.

2-64. In order that the FR-38/U may follow the slowest changing waveforms, the period and 10-period average input circuits are direct-coupled and are designed to trigger at the zero-volt crossing of a negative-going voltage. Any d-c component in the input signal will shift the triggering level so that the maximum slope no longer occurs at the zero-volt level, resulting in a loss of accuracy.

2-65. The above figures are for a pure sine wave in the absence of noise. The additional error due to superimposed noise is given by:

$$\text{Maximum additional possible error} \quad \frac{23 \times \text{peak noise voltage}}{\text{No. of Periods} \times \text{RMS signal voltage}}\ \%$$

2-66. The accuracy of triggering is considerably improved where the waveforms being measured have a sharp rise-time of high slope as they pass through zero-volt level. For example, a significant reduction in error can be obtained when square waves instead of sine waves are used as the input signal. Square waves or pulse repetition rates in excess of 316 pulses per second are more accurately determined by direct frequency measurement.

2-67. STEP-BY-STEP PROCEDURE FOR PERIOD MEASUREMENT.

2-68. A summary of specifications and a step-by-step operating procedure for period measurement is given in paragraph 2-116.

2-69. TIME INTERVAL MEASUREMENT.

2-70. Time interval measurements are similar to period measurements except that the point on the signal waveform or waveforms at which the measurement starts and stops is adjustable. This adjustable

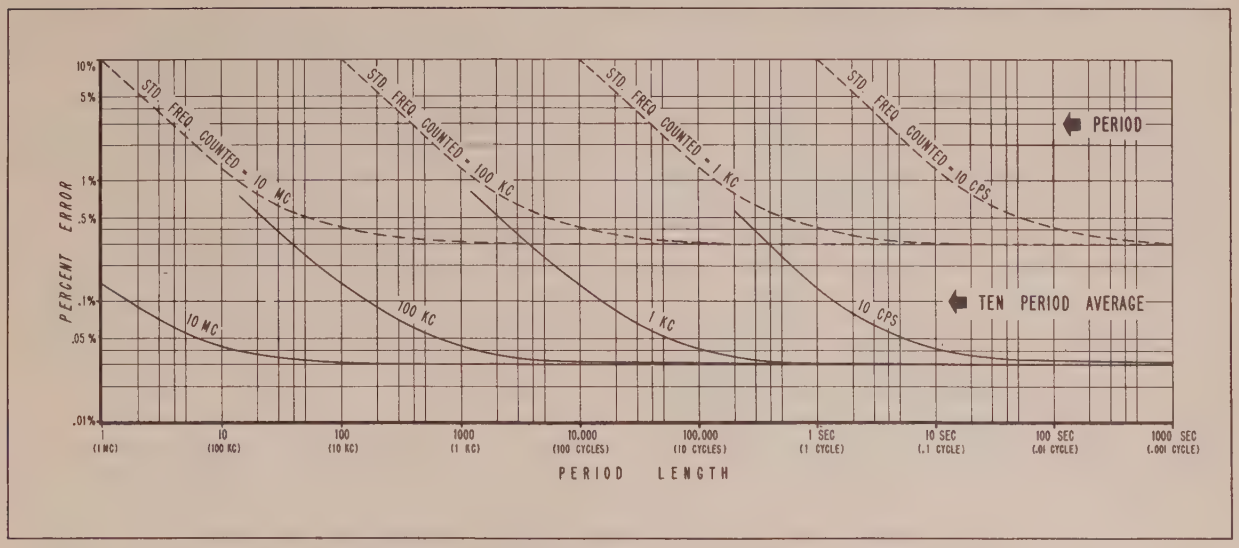


Figure 2-7. Period Measurement Accuracy Curves

threshold feature permits separate signals to be used as start and stop signals or permits measurements to be made from one part of a waveform to another part of the same waveform.

2-71. As in the case of period measurement, the input signals control the opening and closing of the gate while the standard frequencies are passed to the counters, as indicated in the block diagram of Figure 2-8. Thus, the accurate frequencies generated in the time base are used as units of time to measure the unknown interval in terms of microseconds, milliseconds, or seconds.

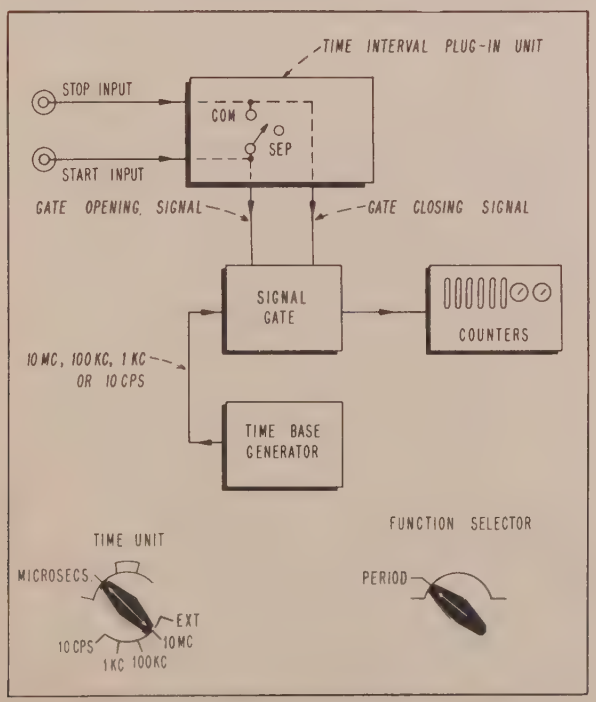


Figure 2-8. Time Interval Measurement, Circuit Block Diagram

2-72. The special threshold-selecting controls adjust the start and stop channels so that they will be actuated only by signals of pre-determined polarity, amplitude, and slope. Two sets of controls are provided to permit each channel to be operated by separate waveforms. Each set consists of a trigger slope selector and a trigger level selector.

2-73. The trigger slope switch prepares the channel to trigger only from the positive-going or only from the negative-going slopes of the signal waveform. The voltage at which the channel will trigger (anywhere from -200 to +200 volts peak) is selected by the trigger level controls. The two sets of controls thus permit each channel to be triggered from any one of four combinations of slope and polarity: Positive or negative slopes of positive voltages, or positive or negative slopes of negative voltages. For each of these combinations the voltage level at which triggering occurs is adjustable from -200 volts through 0 volts to +200 volts.

2-74. CONTROLS AND TERMINALS USED FOR TIME INTERVAL MEASUREMENTS. (See Figure 2-1.)

2-75. The FUNCTION SELECTOR (7) is the master control and must be set to PERIOD for time interval measurement.

2-76. The TIME UNIT (8) switch selects the standard frequency to be counted, indicates the unit of time in which the measurement is presented, and locates the illuminated decimal point. Four internal standard frequencies can be used: 10 megacycles, 100 kc, 1 kc, and 10 cps. These frequencies correspond to time units of microseconds (in units of 0.1 microsecond), milliseconds (in units of 0.01 milliseconds or 1.0 milliseconds), and seconds (in units of 0.1 second). The greatest accuracy of measurement is obtained when using the frequency that gives the highest number of counts on the display system.

2-77. The EXT position of the TIME UNIT switch permits an external frequency to be counted in place of the internal standard frequencies. This arrangement permits use of an external frequency that may have special relation to the interval being measured, i.e., the displayed reading will be in units of feet, yards, miles, etc. The standard frequencies selected by the Time Unit switch are available for external use at the STD. FREQ. OUTPUT (9) connector. This same connector serves as the input connector when the EXT position of the TIME UNIT switch is used. Details of voltages and impedance involved are described in paragraph 2-107. It should be noted that the STD. FREQ. OUTPUT connector is direct-coupled when it is used as an input connector; therefore, it is important that the input signal be free from d-c voltages. If necessary, a blocking capacitor should be connected in series with the connector externally to block any external dc. The amplitude of the signal voltage applied must lie between 1.5 and 10 volts peak.

CAUTION

The load impedance of STD. FREQ. OUTPUT connector J-205 is approximately 1000 ohms. Excessive loading resistively or capacitively (by long cable lengths) of J-205 must be avoided since it will also load the internal standard frequencies counted during Period, Time Interval, or Manual Gate operations and cause erratic count. During any operation where internal standard frequencies are counted, it may be necessary to remove cables from STD. FREQ. OUTPUT to obtain correct readings.

2-78. The automatic display time is adjustable from at least 0.3 to 5 seconds (DISPLAY TIME 13). A longer display time may be obtained by setting the display time control to INF. In this position a count will be displayed until the RESET (14) is pressed, which resets the counters to zero and allows a new count to start.

2-79. Separate "start" and "stop" input channels and their special threshold-selecting controls are contained in the TIME INTERVAL UNIT. The signal that is to start the measurement is connected to the START INPUT (32) connector. The input signal slope (positive-going or negative-going), from which it is desired to start the measurement, is selected by the TRIGGER SLOPE (33) switch. The voltage level (anywhere between -200 and +200), at which the measurement is to begin, is selected by TRIGGER LEVEL (34 and 35) controls. The signal that is to stop the measurement is connected to STOP INPUT (38), and the "threshold" is selected in the same manner as it was for the start channel using the stop channel TRIGGER SLOPE (39) and TRIGGER LEVEL VOLTS controls (40 and 41). If the input signals are taken from separate sources, the COM SEP (37) switch is placed in the SEP position. If both input signals originate from the same source, the COM SEP (37) switch is placed in the COM position and either the START INPUT or the STOP INPUT connector may be used. The COM SEP switch shorts the two input connectors together when in the COM position.

2-80. The TIME INTERVAL - PERIOD (31) switch, when in the TIME INTERVAL position, connects the adjustable threshold circuits to the gate control circuits and connects, when in the PERIOD position, the SIGNAL INPUT (12) to the gate control system. Time interval measurements can be made only when the TIME INTERVAL - PERIOD switch is in the TIME INTERVAL position.

2-81. The START INPUT and STOP INPUT connectors each have an input impedance of approximately 1 megohm shunted by 20-40 micromicrofarads. When the SEP - COM switch is in the COM position, these impedances are paralleled, giving an input impedance of approximately 0.5 megohm shunted by 40-80 micromicrofarads.

2-82. TIME INTERVAL MEASURING TECHNIQUES.

2-83. Time interval measurements begin when the start signal crosses the selected start threshold value in the selected direction and end when the stop signal crosses the selected stop threshold value in the selected direction. The threshold values are indicated by the calibration of the threshold controls. It should be noted, however, that the calibration of these controls is only approximate and that in some applications it will be necessary to take special precautions in order to obtain a measurement of the desired interval.

2-84. The input circuits in the Time Interval Unit are direct-coupled and will therefore pass d-c voltages as well as a-c voltages. When a pulse or other signal is superimposed on a d-c voltage, then it will be necessary to set the threshold controls accordingly (or to remove the d-c component with an external blocking capacitor).

2-85. If an uncomplicated waveform is being used as the start and/or stop signal, the threshold controls can usually be adjusted without special precautions. For example, if a sharp pulse like that shown in Figure 2-9 is used, there will be little difference whether the measurement begins at point A or point B.

2-86. If a more complex waveform like that shown in Figure 2-10 is being used, however, greater care must

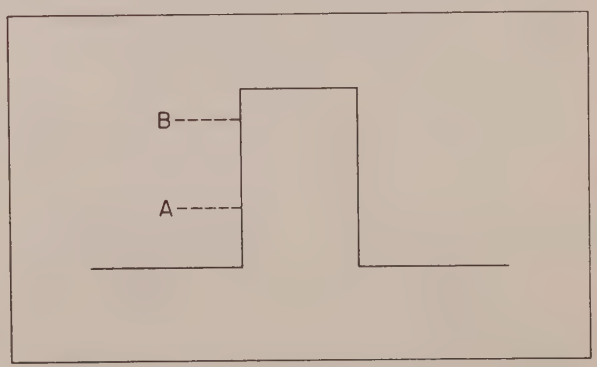


Figure 2-9. Time Interval Measurement of Uncomplicated Waveform

be taken to avoid measuring an undesired value. If it is desired to measure the interval "x", for example, an inadvertent measurement of "y" can easily be made. To avoid measuring an undesired interval in such a case, it is desirable to set the threshold controls near zero as a preliminary adjustment so that a measurement of "y" will be obtained. If the settings of the start threshold controls are then increased, a point will be observed where the start measurement suddenly changes from below the step in the waveform to the rise that is above the step. This change will be reflected in a change in the measured time interval. Similarly, the stop threshold controls can be increased until a discrete change occurs in the measured value.

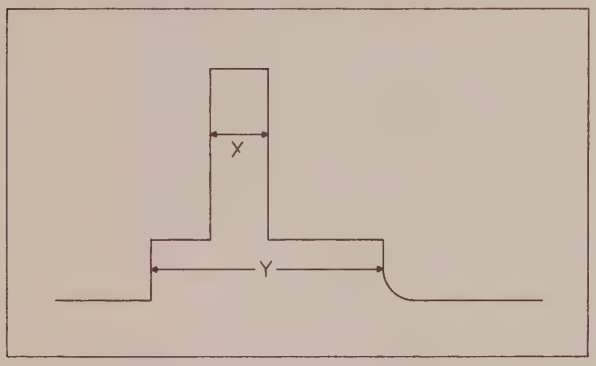


Figure 2-10. Time Interval Measurement of Complex Waveform

2-87. By exercising similar precautions with other complex waveforms, accurate measurements can usually be obtained without difficulty.

2-88. Occasionally, spurious signals will accompany start and stop signals. If these spurious signals have characteristics that appear to the start or stop channels as genuine start or stop signals, the measurement obtained will be an accurate measurement, but will not be a measurement of the desired interval. It is therefore highly desirable that the start and stop signals be carefully examined on an oscilloscope before attempting a measurement, both to determine that the signals are free from spurious signals and so that the waveform will be known accurately.

2-89. STEP-BY-STEP PROCEDURE FOR TIME INTERVAL MEASUREMENT.

2-90. A summary of specifications and a step-by-step operating procedure for time interval measurements are given in paragraph 2-116.

2-91. MEASURING TOTAL EVENTS.

2-92. The FR-38/U can be used as a high-speed totalizer capable of counting at a maximum rate of 10 million events per second. The maximum capacity of the display system is 99,999,999 counts, returning to 00,000,000 on the one hundred millionth count. The resolution time of the instrument is 0.1 microsecond for double pulses and 0.2 microsecond for triple pulses. The waveform of the electrical events to be counted must have a rise time of not less than 1 millisecond, and a minimum amplitude of 1.5 volts peak. Maximum allowable amplitude for this purpose is 10 volts peak.

2-93. Figure 2-11 shows the basic circuit arrangement of the equipment when used as a totalizer. The opening and closing of the signal gate is controlled manually, while the signal to be counted is connected through the STD. FREQ. OUTPUT connector (9). The TIME UNIT switch (8) must be in the EXT position.

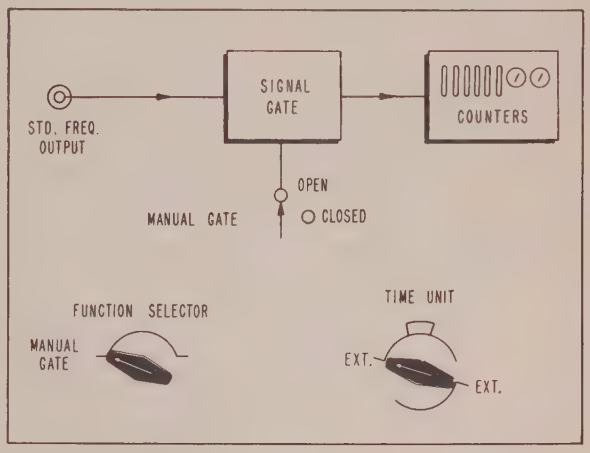


Figure 2-11. Totalizing Measurement, Circuit Block Diagram

2-94. CONTROLS AND TERMINALS USED FOR TOTALIZING. (See Figure 2-1.)

2-95. The FUNCTION SELECTOR (7) must be set to the MANUAL GATE position when totalizing. In this condition the signal gate can only be opened and closed by the MANUAL GATE switch.

2-96. The TIME UNIT switch (8) must be placed in the EXT position. This permits the signal to be counted to be introduced through the STD. FREQ. OUTPUT connector (9) which can be gated with the MANUAL GATE switch.

2-97. The MANUAL GATE switch (24) is effective only when the FUNCTION SELECTOR is in the MANUAL GATE position. The MANUAL GATE switch interrupts the circuit between the STD. FREQ. OUTPUT connector and the signal gate and thus begins and ends a totalizing measurement.

2-98. STEP-BY-STEP PROCEDURE FOR TOTALIZING MEASUREMENT.

2-99. A summary of specifications and a step-by-step operating procedure for totalizing measurement are given in paragraph 2-116.

2-100. TIME AND FREQUENCY RATIO MEASUREMENT.

2-101. Another valuable feature of the FR-38/U is its ability to measure the ratio of two frequencies. As illustrated in Figure 2-12, the higher of the two

frequencies is connected to the EXT channel of the TIME UNIT switch and passed through the signal gate to the counters. This signal is counted for a period of time determined by either one period or ten periods of the lower frequency, which controls the opening and closing of the gate.

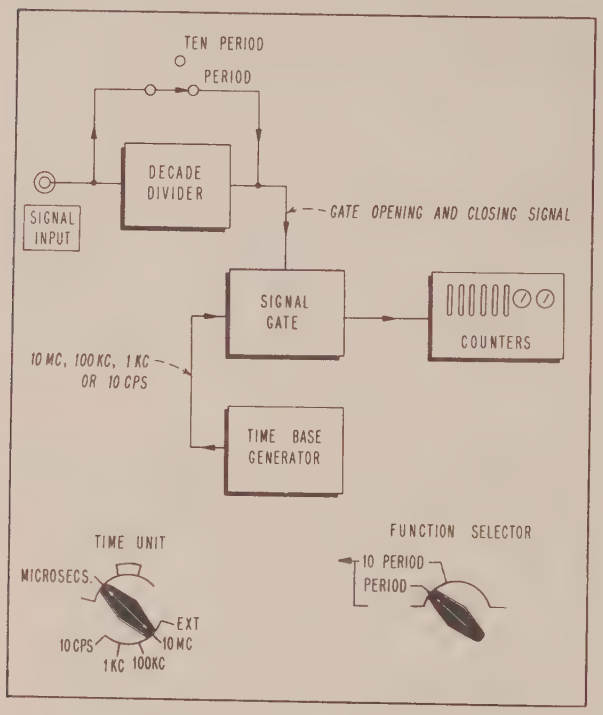


Figure 2-12. Ratio Measurement, Circuit Block Diagram

2-102. CONTROLS AND TERMINALS USED FOR RATIO MEASUREMENT. (See Figure 2-1.)

2-103. The FUNCTION SELECTOR (7) is the master control and must be set to either PERIOD or 10 PERIOD AVERAGE for ratio measurement. When the PERIOD position is used, the counters display the number of cycles of the higher frequency per cycle of the lower frequency. In the 10 PERIOD AVERAGE position the counters display the number of cycles of the higher frequency per 10 cycles of the lower.

2-104. When the instrument is used to measure ratios, the TIME UNIT (8) switch is placed in the EXT position and the higher of the two input frequencies is introduced through the STD. FREQ. OUTPUT (9) connector. The illuminated decimal point is disabled.

2-105. The automatic display time is adjustable from 0.3 to 5 seconds (DISPLAY TIME 13). Longer display time may be obtained by setting the display time control to INF. In this position a count will be displayed until the RESET (14) button is pressed, which resets the counters to zero. Use the INF position if the period of the lower input frequency exceeds approximately one second.

2-106. As the panel plug-in units take no active part in ratio measurement, either unit may be used. One or the other of the units must be in place, however. Turn the instrument off when changing plug-in units. With one exception, the controls of the panel plug-in units are not used. The one exception is that the TIME INTERVAL - PERIOD (31) switch on the Time Interval Unit must be in the PERIOD position.

2-107. The STD. FREQ. OUTPUT (9) connector is used as the input connector for the higher of the two input frequencies, which may be as high as 10 mc or as low as 10 cps. The input signal must have a rise time of at least one millisecond, a minimum amplitude of 1.5 volts peak, and a maximum amplitude not in excess of 10 volts. The input impedance of the connector is 1 megohm shunted by 100 μμf. The circuits behind this connector are direct-coupled so that no d-c component should be present in the applied signal. If necessary, an external blocking capacitor should be used to block out a d-c component.

2-108. The SIGNAL INPUT (12) connector is used as the input connector for the lower of the two input frequencies. The lower frequency may be as high as 10 kc or as low as 0.01 cps. It must not be less than 1.5 volts peak nor more than 280 volts peak. It may have any rise time, although maximum accuracy requires fast rise time. The input impedance is approximately 1 megohm shunted by 40 μμf.

2-109. The time base generator is not used when making ratio measurements. If an external 100 kc standard is connected to the instrument, however, there is no need to disconnect it.

2-110. RATIO MEASUREMENT ACCURACY.

2-111. Ratio measurement accuracy is determined by the same factors as period measurement accuracy: Consistency of triggering by the lower input frequency and the inherent error of ±1 count of the higher input frequency. The error due to inconsistency of triggering, as explained in paragraph 2-63, has been held to ±0.3% for a sine wave input of 1 volt rms for single period measurement, and to ±0.03% when 10 periods are measured.

2-112. As smaller and smaller ratios are measured, the tolerance of ±1 count becomes increasingly important on a percentage basis. Thus, when neasuring the ratio of 100:1 (e.g., 1000 cps to 10 cps), the ±1 count tolerance would result in a possible error of 1% for single period or 0.1% for 10-period measurement.

2-113. Figure 2-13 shows the total error for ratio measurements for the range from 100,000,000 to 1 to 10 to 1 for a lower frequency input of 1 volt rms sine wave. Single period error is shown in dotted line while 10 period error is shown in solid line. The error can be significantly reduced by use of higher input voltages with fast rise times.

2-114. STEP-BY-STEP PROCEDURE FOR RATIO MEASUREMENT.

2-115. A summary of specifications and a step-by-step operating procedure are given in paragraph 2-116.

2-116. SPECIFICATION SUMMARY.

2-117. A summary of specifications and step-by-step operating procedures for all of the measurement functions performed by the AN/USM-26 are given in the following pages of this section.

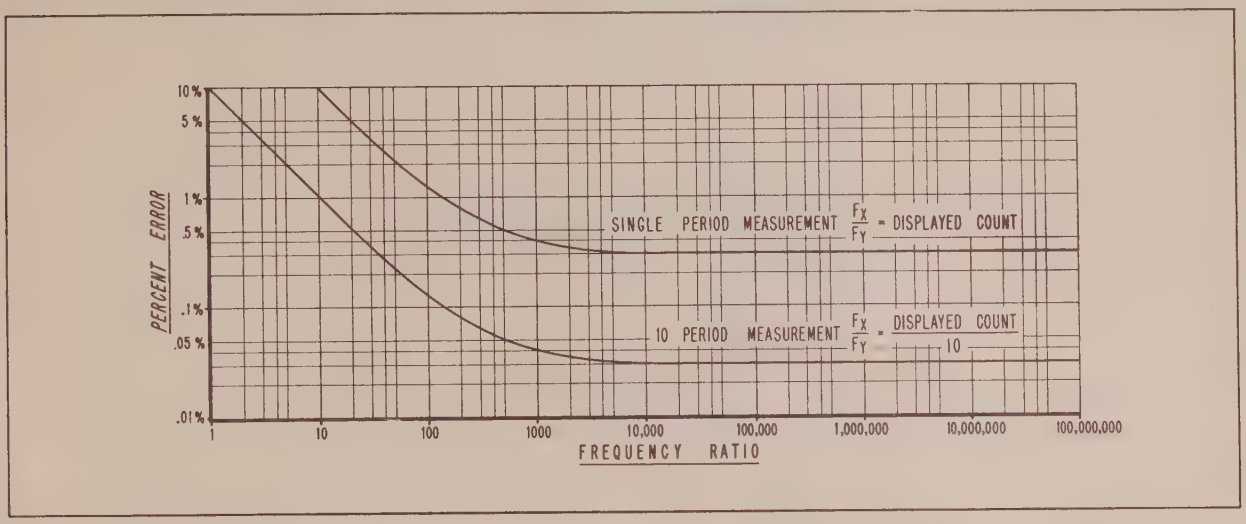


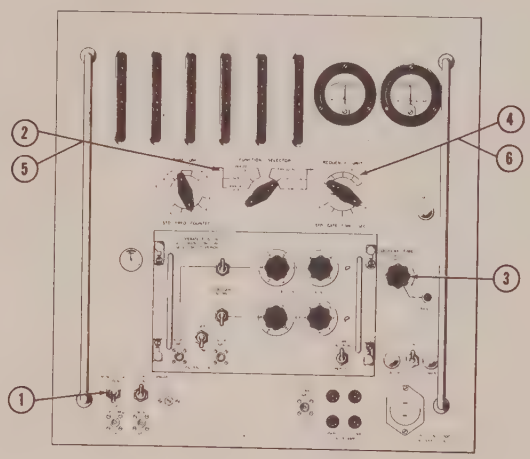
Figure 2-13. Ratio Measurement Accuracy Curves

PRELIMINARY SET-UP INSTRUCTIONS FOR ALL MEASUREMENTS

A. If internal 100 kc frequency standard is being used, make certain crystal oven thermometer reads 65° ±5°C (149° ±9°F). If external standard is used, make certain 100 KC STANDARD switch is in EXT position.

B. Turn off power switch and install proper panel plug-in unit. Then turn on power switch and allow a warm-up period until proper readings on 100 kc and 10 mc self-check are consistently obtained. Repeat self-check occasionally.

PROCEDURE FOR SELF-CHECK



1. Set MANUAL GATE switch to CLOSED.

2. Set FUNCTION SELECTOR switch to 100 KC CHK.

3. Adjust DISPLAY TIME control for desired display time (usually CCW).

4. Note reading on display system for each position of FREQUENCY UNIT switch. These readings should agree with the table below. Check phantastron circuit adjustments if readings do not agree with the table.

5. Now set FUNCTION SELECTOR switch to 10 MC CHK.

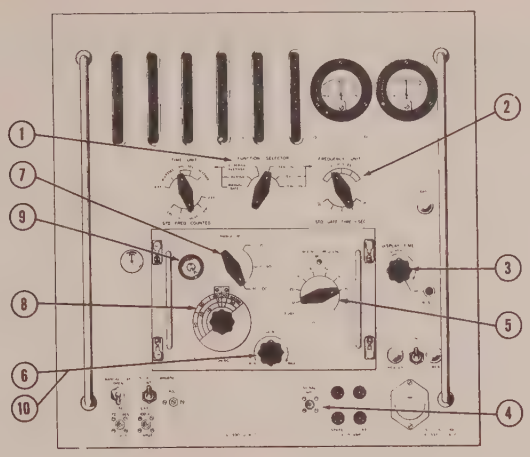
6. Repeat step 4. When checking 10 mc, note that a discrepancy of ±1 count in the last digit is acceptable because of inherent error due to the counting system.

7. If correct readings are obtained, the equipment can be considered to be operating properly. If readings are incorrect, the instrument should be turned over to servicing personnel.

Counter Readings for Self-Check Operations

GATE TIME	100 KC CHECK	10 MC CHECK
10 sec	0100.0000	0000.0000 ± .0001
1 sec	00100.000	10000.000 ± .001
0.1 sec	000100.00	010000.00 ± .01
0.01 sec	0000100.0	0010000.0 ± .1
0.001 sec	00000100.	00010000. ± 1

PROCEDURE FOR FREQUENCY MEASUREMENT



PROCEDURE 1. 10 CPS - 10.1 MC

Any plug-in unit may be used. Sensitivity with Time Interval unit is 1 volt rms. Frequency Converter Unit affords variable sensitivity down to 0.2 volts rms.

PROCEDURE 2. 10.1 MC - 100 MC

Frequency Converter plug-in unit must be used. Sensitivity 0.02 volt rms.

PROCEDURE 1.

1. Set FUNCTION SELECTOR switch to FREQUENCY.

2. Set FREQUENCY UNIT switch to desired gate time (usually 1 or 10 seconds).

3. Set DISPLAY TIME control to desired display time (usually CCW).

4. Connect signal to SIGNAL INPUT.

Note: If FREQUENCY CONVERTER unit is used, set MIXING FREQUENCY control to "O" and adjust GAIN control until tuning eye just closes.

PROCEDURE 2.

1. Set FUNCTION SELECTOR switch to FREQUENCY.

2. Set FREQUENCY UNIT switch to desired gate time (usually 1 or 10 seconds).

3. Set DISPLAY TIME control to desired display time (usually CCW).

4. Connect signal to SIGNAL INPUT.

5. Set MIXING FREQUENCY switch to TUNE.

6. Set GAIN control to maximum clockwise position.

7. Set RANGE - MC switch to 10-20 position.

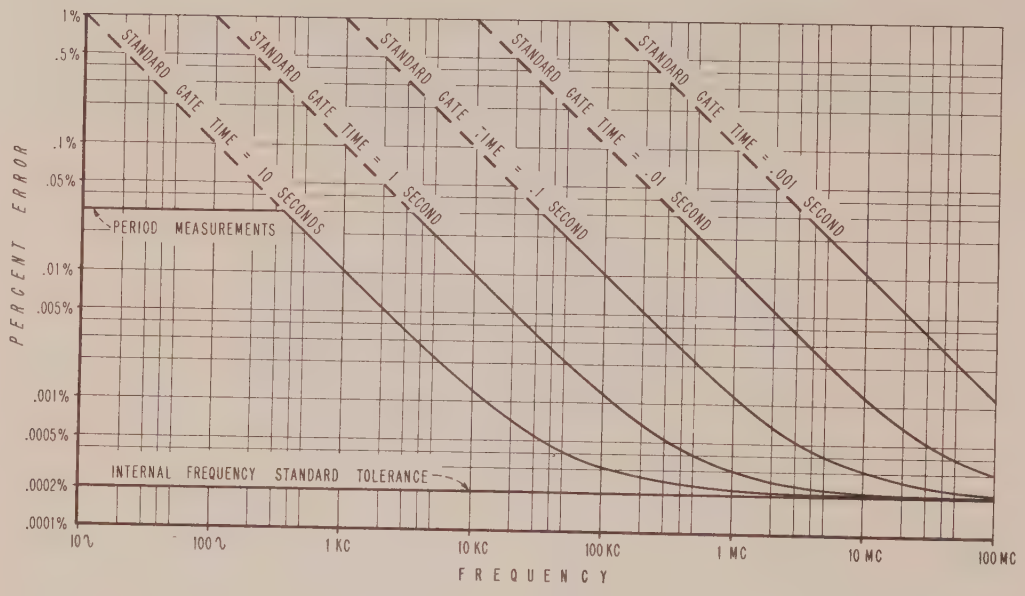
8. Set TUNING control to left end of "10" region. Adjust control slowly until minimum shadow is obtained on tuning eye, changing RANGE - MC switch as necessary. If eye overlaps, reduce GAIN control setting and retune TUNING control.

9. When indication on eye is observed, set MIXING FREQUENCY control to position indicated by TUNING dial.

10. Adjust GAIN control until eye just closes, but does not overlap.

11. Unknown frequency is read by adding reading of MIXING FREQUENCY switch (frequency in megacycles) to reading on display system (frequency in kilocycles).

PROCEDURE FOR FREQUENCY MEASUREMENT (Continued)



Frequency Measurement Accuracy Curves

Reference Table for Measuring Frequency with Frequency Converter Unit

Required Input Signal:	Below 10 Mc: at least 0.2 volt rms. 10 Mc to 100 Mc: 0.02 volt rms. Maximum - 200 volts peak.
Input Impedance:	Below 10 Mc: approximately one megohm shunted by 40 mmf. 10 - 100 Mc: approximately 50 ohms.
Frequency Measurement Range:	10 cps to 100 megacycles.
Accuracy:	±0.0002% ±0.1 cps on 10-second gate.

PROCEDURE FOR PERIOD MEASUREMENT

1. Any plug-in unit may be used. If Time Interval unit is used, set TIME INTERVAL - PERIOD switch to PERIOD.

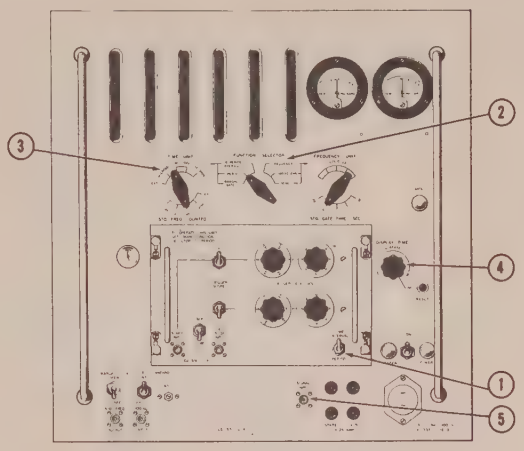
2. Set FUNCTION SELECTOR switch to PERIOD or 10 PERIOD AVERAGE.

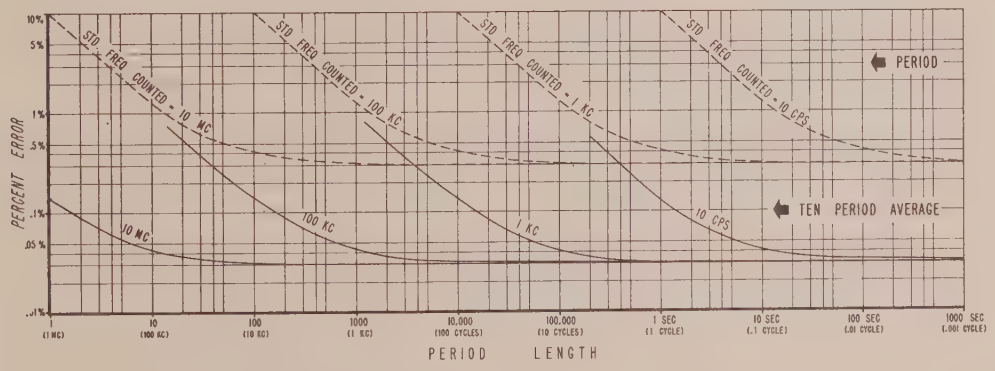
3. Set TIME UNIT switch to desired time units (usually largest number of count).

4. Set DISPLAY TIME control for desired display time (usually CCW).

5. Connect signal to SIGNAL INPUT.

6. Period of frequency being measured will now be indicated on display system in units selected by setting of TIME UNIT switch.





Period Measurement Accuracy Curves

Reference Table for Measuring Period

Required Input Signal:	Minimum: 1 volt rms Maximum: 200 volts rms
Input Impedance:	Approximately 1 megohm shunted by 40 mmf
Period Measurement Range:	100 microseconds to 100 seconds (0.01 cps - 10 kc)
Accuracy:	±0.03% ±0.1 microsecond

PROCEDURE FOR TIME INTERVAL MEASUREMENT

1. Time Interval plug-in unit must be used. TIME INTERVAL - PERIOD switch must be in TIME INTERVAL position.

2. Set FUNCTION SELECTOR switch to PERIOD.

3. Connect signals to START INPUT and STOP INPUT.

4. Set SEP-COM switch to SEP.

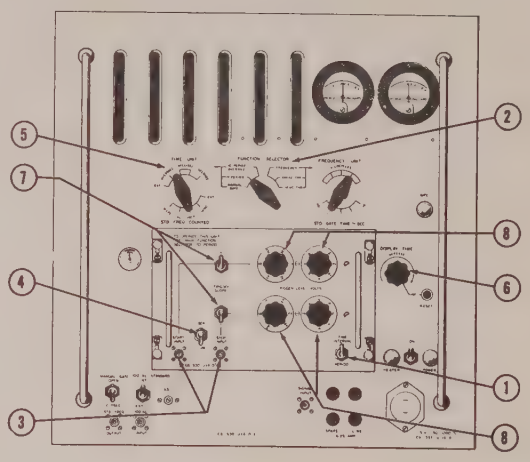
Note: If start and stop signals are from same source, either input connector can be used and SEP-COM switch set to COM.

5. Set TIME UNIT switch to desired time unit (usually for largest number of counts).

6. Set DISPLAY TIME control for desired display time (usually CCW).

7. Set start and stop channel TRIGGER SLOPE switches for measurement start point (positive-going or negative-going slope).

8. Adjust TRIGGER LEVEL controls for measurement start point (voltage level -200 to +200 volts).



9. Measured time interval will now be displayed in time units selected by TIME UNIT switch.

Reference Table for Measuring Time Interval

Required Input Signal:	Minimum: 2 volts peak Maximum: ±200 volts peak
Input Impedance:	1 megohm shunted by 20 to 40 mmf approximately (each channel)
Time Interval Range:	1.0 microsecond to 10,000,000 seconds
Control Range for Independent Start and Stop Channels:	Trigger for either positive-going or negative-going input voltages at levels from -200 to +200 volts. Separate or common direct coupled inputs.
Accuracy:	0.1 microsecond ±0.0002% (when counting 10 mc fast rise time pulses). The trigger level controls are accurate to about 20% ±0.2 volts variation in the zero level.

PROCEDURE FOR TOTALIZING

1. Any plug-in unit may be used.

2. Set FUNCTION SELECTOR to MANUAL GATE.

3. Press RESET button to clear counter.

4. Set TIME UNIT switch to EXT.

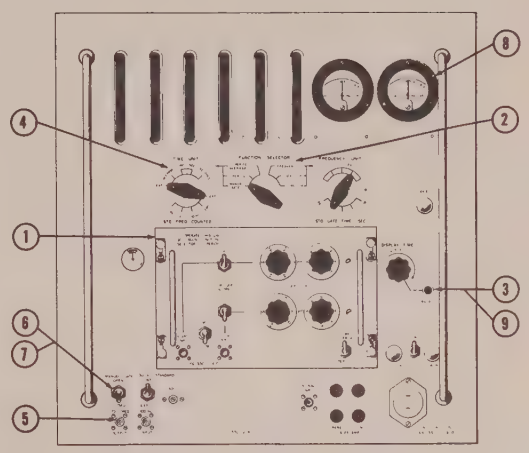
5. Connect signal to be counted to STD. FREQ. OUTPUT.

6. To begin count, set MANUAL GATE switch to OPEN.

7. To end count, set MANUAL GATE switch to CLOSED.

8. The total number of pulses received during counting period will now appear on counter.

9. Clear counter by pressing RESET button.



Reference Table for Totalizing

Input Signal:	Minimum:	1.5 volts peak
	Maximum:	10 volts peak
	Minimum Rise Time:	1 millisecond
Input Impedance:	1 megohm shunted by 100 micro-microfarads	
Counting Capacity:	100,000,000 after which it recycles	
Resolution:	Double pulse - 0.1 microsecond Triple pulse - 0.2 microsecond	

PROCEDURE FOR MEASURING RATIO

1. Any plug-in unit may be used.

2. Set FUNCTION SELECTOR switch to PERIOD or 10 PERIOD AVERAGE.

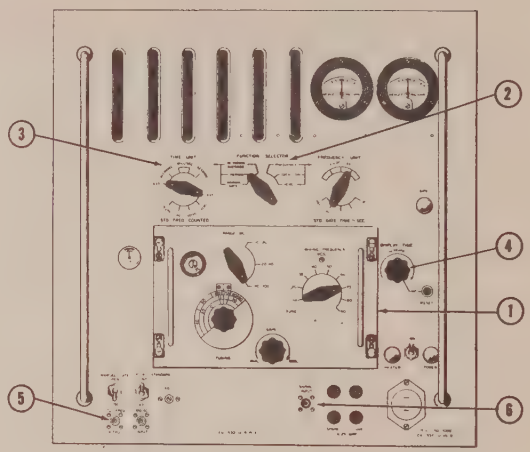
3. Set TIME UNIT switch to EXT.

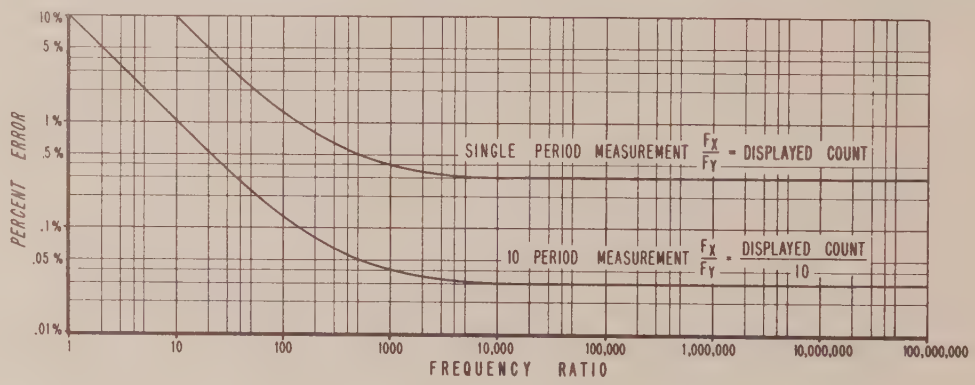
4. Set DISPLAY TIME control for desired display time (usually CCW).

5. Connect higher of two input frequencies to STD. FREQ. OUTPUT.

6. Connect lower of two input frequencies to SIGNAL INPUT.

7. Number of cycles of the higher input frequency per cycle or per 10 cycles of the lower input frequency is automatically measured and answer displayed.





Ratio Measurement Accuracy Curves

Reference Table for Ratio Measurements

	Higher Frequency	Lower Frequency
Required Input Signal:	Minimum: 1.5 volts peak Maximum: 10 volts peak Minimum rise time: 1 millisecond	Minimum: 1.5 volts peak Maximum: 280 volts peak Rise time: Any
Input Impedance:	1 megohm shunted by 100 mmf	1 megohm shunted by 40 mmf
Ratio Measurement Range:	10 mc per second to 10 cps	10 kc to 0.01 cps
Accuracy:	±0.03% of the total count ±1/total count, for 10 period measurement with one volt rms sine wave	

SECTION III

OPERATING CHECKS AND ADJUSTMENTS

3-1. GENERAL.

3-2. The following paragraphs describe operating checks that should be made prior to actual operation. These checks are required to maintain the accuracy of the instrument.

3-3. STABILIZING THE 100 KC CRYSTAL. After installing the equipment, it usually requires several days of operation for the crystal in the internal frequency standard to reach its specified stability of 2 parts per million per week.

3-4. STANDARDIZING THE 100 KC CRYSTAL OSCILLATOR. In order to maintain the accuracy of the FR-38/U, the internal 100 kc crystal-controlled oscillator should be standardized at regular intervals unless an external frequency standard is being used. The long-time drift of the oscillator is within ±2 parts per million per week. If maximum accuracy is to be maintained, therefore, the oscillator should be standardized approximately once a week. Because of the importance of maintaining the accuracy of the oscillator, the adjusting process has been made simple.

3-5. There are two methods for standardizing the oscillator. The first method consists of measuring an accurately-known standard frequency and adjusting the oscillator until the FR-38/U reads correctly. The other method uses a communication type radio receiver to beat a harmonic of 100 kc internal standard with National Bureau of Standards Station WWV.

CAUTION

The first method of standardizing the oscillator is only satisfactory as long as the external standard frequency used is known to be more accurate than the FR-38/U. The FR-38/U is a very accurate instrument, and one of the common causes of inoperation occurs from attempting to standardize it against less accurate equipment. Since the FR-38/U is generally more accurate than any frequency standard available at most naval installations, the second method will usually have to be used.

3-6. METHOD I. The quicker of the two possible methods for standardizing the internal oscillator is to apply to the FR-38/U for counting, an external standard frequency of high accuracy. The internal oscillator can then be adjusted until the reading obtained on the counter is accurate. The external standard frequency to be used will usually be available only from an external frequency standard and should have the following characteristics:

a. It should be not less than 1 megacycle nor more than 10 megacycles. A frequency of 10 megacycles is ideal for standardizing.

b. It should be accurate within approximately 8 to 10 parts in 10^7. However, if the FR-38/U has not been standardized for an extended interval, such as three months, a standard frequency of less precision may be useful.

c. It must have an amplitude of at least 0.2 volt rms when applied to the SIGNAL INPUT terminal of the FR-38/U. At this connector the input impedance is 1 megohm shunted by approximately 40 μμf. This assumes that the Frequency Converter is in place.

d. It must have a signal/noise ratio of at least 40 db.

3-7. PROCEDURE FOR STANDARDIZING USING METHOD I.

a. The FR-38/U must be thoroughly heated. If it is being standardized for the first time, it should be allowed to operate continuously (POWER switch in standby or down position) for at least several days before the standardization can be considered complete.

b. Install the Frequency Converter plug-in unit. Turn off power switch before removing or installing.

c. Self-check the instrument as described in paragraph 2-14. If the self-check does not show the equipment to be operating properly, the trouble must be repaired before proceeding.

d. Apply the standard frequency to the SIGNAL INPUT terminal of the FR-38/U.

e. Set FUNCTION SELECTOR switch to FREQUENCY.

f. If a 10-megacycle standardizing frequency is being used, set FREQUENCY UNIT switch for a 1-second gate time. If a 1-megacycle standardizing frequency is being used, set FREQUENCY UNIT switch for a 10-second gate time.

g. Set DISPLAY TIME control fully counterclockwise.

h. Using a screwdriver, turn ADJ control at lower left of front panel until counter reading is accurate, paying particular attention to the accuracy of the two meter readings. The ADJ control is provided with a 5/16-inch locknut. However, this nut has been set at the factory so that it acts as a high-torque device and does not lock firmly. If the setting of the nut has been subsequently tightened, it must be loosened before making the adjustment.

i. The control should be adjusted so that the reading on the counters is 10,000,000 if a 1-megacycle or 10-megacycle standardizing frequency is being used. If other than these values are being used, the control should be adjusted until the counter reading accurately displays the frequency used.

j. If a 10-megacycle frequency is being used, the above procedure requires that the adjustment be made using a 1-second gate. After the adjustment has been made, the FUNCTION SELECTOR can be set for a 10-second gate and the reading on the counters noted. The reading should be within ±10 of 100,000,000. Ordinarily, the reading will be within ±1 part of 100,000,000.

3-8. METHOD II. The second method for standardizing the internal oscillator is to zero-beat the oscillator against Bureau of Standards Station WWV, using a communications receiver to detect the beat. The internally-generated 100 kc frequency is available at the STD. FREQ. OUTPUT connector on the front panel and has sufficient harmonic content so that a beat can be obtained at least as high as the 10-megacycle transmission from WWV. It should be noted that, although WWV is rated as accurate within 2 parts in 10^8, doppler effects in the transmission reduce this accuracy. As a result, the received frequency is usually accurate within a few parts in 10^8, although on occasion it may be worse.

3-9. PROCEDURE FOR STANDARDIZING USING METHOD II.

a. Follow steps a through c from paragraph 3-7 above.

b. Set TIME UNIT switch to 100 kc.

c. Set 100 KC STANDARD switch to INT position.

d. Couple the 100 kc signal from the STD. FREQ. OUTPUT connector to the antenna of a communications receiver. This coupling should be loose and can ordinarily be made by running a single wire from STD. FREQ. OUTPUT near the antenna lead-in. If additional coupling is required, the wire can be wrapped a few times loosely around the lead-in.

e. Adjust the receiver so that the beat can be heard.

f. Turn ADJ control at lower left of front panel with a screwdriver until zero beat is obtained. See note in paragraph 3-7h regarding locknut on ADJ control.

3-10. USING AN EXTERNAL 100 KC STANDARD. The FR-38/U is arranged so that it can use an external 100 kc standard frequency in place of the internally-generated 100 kc frequency. This arrangement is provided for situations where there is available an external 100 kc primary frequency standard that has higher accuracy than the internal oscillator which is stable within 2 parts per million per week.

3-11. The external standard frequency should be connected to the 100 KC INPUT connector (23) and must have an amplitude between 1 volt and 10 volts rms at the 100 KC INPUT connector. The input impedance at this connector is 1 megohm shunted by 30 μμf. When using an external standard frequency, the 100 KC STANDARD switch must be in the EXT position.

SECTION IV

EMERGENCY OPERATION AND REPAIR

CAUTION

Frequency Meter AN/USM-26 is a precision measuring instrument equivalent to a high-quality secondary frequency standard. It is strongly recommended that operating personnel do not attempt any maintenance or trouble-shooting work on the equipment beyond the scope of information in this handbook. Experience with this equipment has shown that haphazard replacement of tubes or other components will only obscure any trouble that may occur.

Any test prods used for measurement purposes should be carefully wrapped with electrical insulating tape so that only the extreme tip of the probe is exposed. Accidentally shorting certain circuits to ground or to another circuit, even momentarily, can burn out a large number of the crystal diodes used in the equipment.

4-1. EMERGENCY OPERATION.

4-2. In order to gain access to some of the adjustments described in the following paragraphs, it is necessary to unscrew the cabinet removal screws (shown in Figure 4-1) and slide off the cabinet.

4-3. ADJUSTING THE PHANTASTRONS. The standard gate times that are used for frequency measurements are derived from the internal 100 kc precision crystal oscillator in the FR-38/U. To obtain these gate times, a series of decade frequency dividers known as phantastrons are used. Occasionally, the circuit constants may change with time to the point where the phantastron may begin dividing by a factor of 9 or 11 instead of by 10. If this happens, a simple adjustment will restore the accuracy of the circuit.

4-4. When the dividing factor of a phantastron changes to 9 or 11, the readings obtained when self-checking the equipment will appear to have spurious 9's or 11's

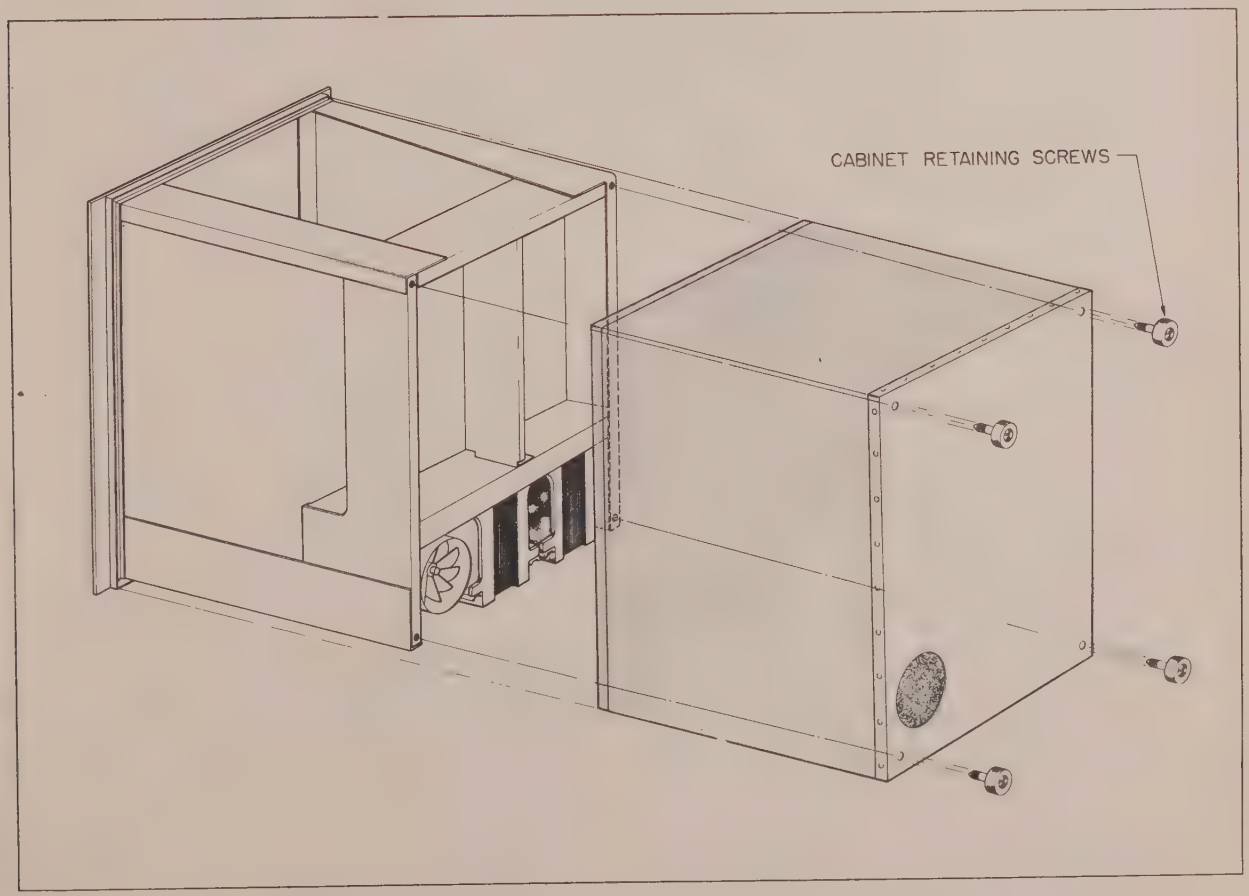
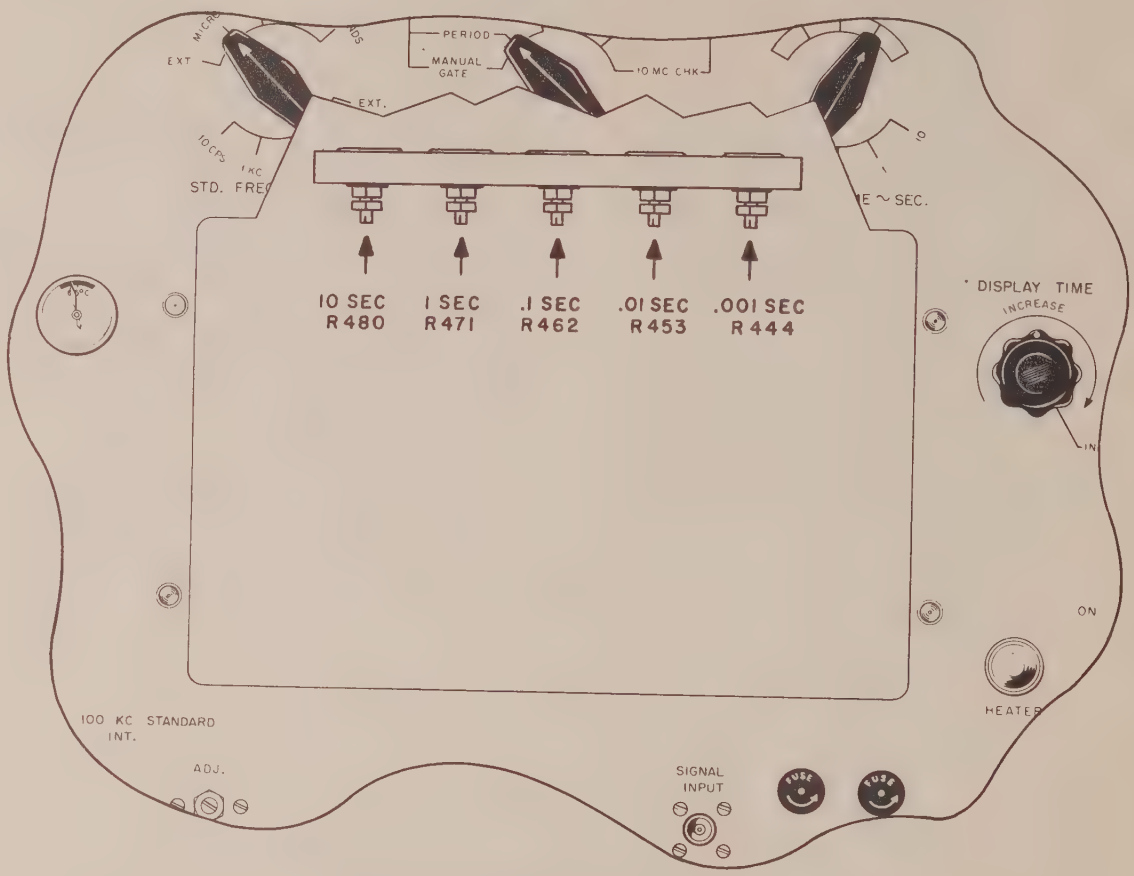


Figure 4-1. Frequency Meter FR-38/U Chassis and Cabinet, Showing Cabinet Removal Screws



PHANTASTRON ADJUSTMENTS

PART NO.	R444	R453	R462	R471	R480
PHAN.	1ST	2ND	3RD	4TH	5TH
GATE TIME	.001 SEC	.01 SEC	.1 SEC	1 SEC	10 SEC
FREQ.	10KC	1KC	100∿	10∿	1∿

Figure 4-2. Phantastron Adjustments, Location Diagram

instead of 10's in the displayed value. To correct this error, the following procedure should be used.

4-5. PROCEDURE FOR ADJUSTING PHANTASTRONS.

a. Turn off POWER switch and remove panel plug-in unit. Turn on POWER switch and allow the instrument to warm up for at least 15 minutes.

b. Set FUNCTION SELECTOR to 100 KC CHECK.

c. Set FREQUENCY UNIT switch to 0.001 second gate time.

d. Set DISPLAY TIME control for minimum display time.

e. Reading on counter should now be 00000100. If a reading such as 00000090 or 00000110 (or even 00000080 or 00000120) is obtained, the first phantastron will require adjusting. A series of potentiometers are provided for adjusting the phantastrons and are located just inside the upper edge of the plug-in aperture in the front panel (Figure 4-2). R-444 should be adjusted until it is set in the center of the region where a stable reading of 00000100 is obtained. The adjusting potentiometers are provided with locknuts, but the locknuts have been set at the factory to have a high-torque effect instead of a locking effect. Consequently, the potentiometers can be adjusted without disturbing the locknut.

f. Set FREQUENCY UNIT switch to 0.01 second gate time.

g. Reading on counter should now be 0000100.0. If the reading is "90.0" or "110.0" instead of "100.0", adjust R-453 (Figure 4-2) in a manner similar to the adjustment of R-444. However, R-453 should be set so that it is in the middle of its region that gives a correct reading on the counters.

h. Set FREQUENCY UNIT switch to 0.1 second gate time.

i. Reading on counter should now be 0000100.00. If reading is "90.00" or "110.00" instead of "100.00", adjust R-462. Set R-462 so that it is in the middle of the region that gives an accurate reading.

j. Proceed in a similar manner for the 1-second and 10-second gate times, setting R-471 and R-480, respectively. Set both potentiometers so that they are in the middle of the regions that give accurate counter readings.

4-6. ADJUSTING GATE LENGTH. R-224 is a screwdriver-operated potentiometer that adjusts the grid bias on the Gate Amplifier V-203. Since the bias on V-203 affects to a slight extent the length of the gate time, it is important that the bias be correct, although, in general, it will only be necessary to reset this bias when replacing V-203 or V-208. The procedure for adjusting the bias on V-203 is as follows:

a. Install one of the panel plug-in units, making certain that the POWER switch is off before the unit is installed.

b. Remove cabinet from FR-38/U. See Figure 4-1 for location of cabinet-securing screws.

c. Turn on the equipment and allow a five-minute warm-up.

d. Set FUNCTION SELECTOR switch to 10 MC CHECK position and set FREQUENCY UNIT switch to 1 second gate position.

e. Adjust GATE LENGTH control R-224 with a screwdriver until the counter reads 10,000.000 ±1. The location of R-224 is shown in Figure 4-3. Note that R-224 is a locking-type potentiometer. The locknut has been set at the factory so that it has high-torque action instead of a locking action. If this adjustment has not been disturbed, it will not be necessary to loosen the locknut.

f. Re-adjust R-224, using the above procedure after 24 hours of continuous operation.

4-7. ADJUSTING BIAS OF TRIGGER UNIT Z-201. The grid bias on V-601B in Trigger Unit Z-201 (signal channel trigger unit) is made adjustable so that the sensitivity of the trigger unit can be adjusted. If this sensitivity adjustment is incorrect, it can cause counting at half the proper rate and at twice the proper rate. Usually, the adjustment is required only when V-601, V-602, or V-603 in the trigger unit is replaced. The procedure is as follows:

a. Install one of the panel plug-in units, making certain that the POWER switch is off before the unit is installed.

b. Remove cabinet from the FR-38/U. See Figure 4-1 for location of cabinet securing screws.

c. Turn on POWER switch and allow equipment to warm up for five minutes.

d. Set FUNCTION SELECTOR to MANUAL GATE position.

e. Set TIME UNIT switch to 100 KC position.

f. Set MANUAL GATE switch to OPEN. A continuously-increasing reading should now be obtained on display system.

g. Adjust FREQ. SENS. potentiometer R-211 (shown in Figure 4-3) with a screwdriver until bias is correct. To do this, first turn R-211 fully counterclockwise and note reading being obtained on the counters. The counter is being supplied with a 100 kc frequency and its reading will increase by 100,000 counts each second. If this is happening, it indicates that circuit is operating satisfactorily except for incorrect bias. Turning R-211 fully clockwise will cause the count to stop. This indicates that range of bias is satisfactory since it has cut off the amplifier in the trigger unit. Next, turn R-211 slowly counterclockwise while watching the counters. At first, the counters will begin an erratic or slow count equal probably to 50 kc. Slowly continue the counterclockwise adjustment until counters operate at the correct rate (i.e., 100 kc each second). Note the two panel meter readings to see that these readings are stable and do not occasionally "jump". If they are slightly erratic, increase counterclockwise setting of R-211 very slightly.

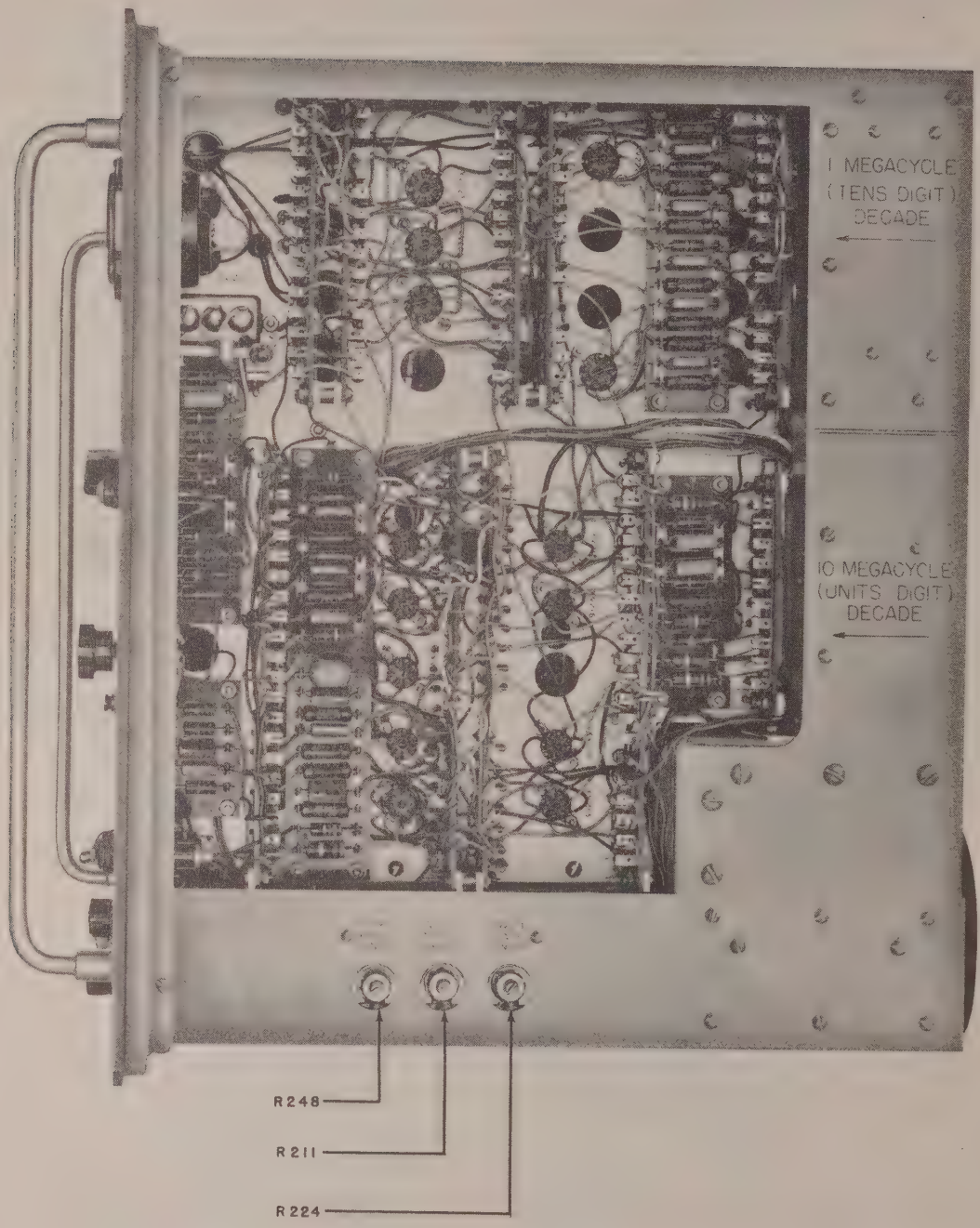


Figure 4-3. Frequency Meter FR-38/U, Right Side View

4-8. ADJUSTING BIAS ON TIME INTERVAL PLUG-IN UNIT. Two screwdriver-operated potentiometers are available at the front panel of the Time Interval plug-in unit. (See Figure 2-1, controls 36 and 42.) These potentiometers affect the accuracy of calibration of the Trigger Level controls on the front of the Time Interval Unit. Although the calibration of these controls is only approximate (within 20%), it is advisable to set the calibration when replacing V-601, V-602, or V-603.

a. If Time Interval panel plug-in unit is not in place, turn off POWER switch and install that unit.

b. With POWER switch off, remove cabinet from the FR-38/U. See Figure 4-1.

c. Turn on POWER switch and allow equipment to warm up for approximately five minutes.

d. Set FUNCTION SELECTOR to PERIOD.

e. Set TIME UNIT switch to 10 MC.

f. Set TIME INTERVAL - PERIOD switch on Time Interval unit to TIME INTERVAL.

g. Set SEP-COM switch on Time Interval unit to COM.

h. Set both TRIGGER SLOPE switches on Time Interval unit so that they indicate same polarity (either + or -).

i. Set both TRIGGER LEVEL controls to 0.

j. Set both TRIGGER LEVEL multipliers to x1.

k. Connect a 1 kc sine wave voltage of approximately 1 volt rms amplitude to START INPUT or STOP INPUT terminal.

l. Now rotate start channel TRIGGER LEVEL control on positive side of zero and note reading of control at which the measurement ceases to recur. Repeat for the negative side of zero.

m. If the two points at which the measurement ceases are not symmetrically located around the zero calibration, adjust R-119 at the upper right of the Time Interval unit panel until this condition is achieved.

n. After the start channel calibration has been adjusted, the procedure can be repeated for the stop channel by adjusting R-107 at the lower right of the Time Interval unit panel until the calibration of the stop channel TRIGGER LEVEL control is symmetrical.

CAUTION

Test prods used with the FR-38/U should be taped with insulating tape so that only the extreme tip of the prod has exposed metal. Accidentally shorting the +70 or +90 volt buses to ground or to the +210 volt bus with a test prod can destroy most of the crystal diodes used in the equipment.

4-9. ADJUSTING POWER SUPPLY VOLTAGES. The power supply section of the FR-38/U provides four regulated d-c voltages: -195, +70, +90, and +210 volts. These voltages are interdependent so that when one voltage is adjusted for any reason, all four voltages should be checked. Usually, it will not be necessary to adjust the power supply voltages except when a tube or other component in the power supply section is replaced. All power supply adjustments are shown in Figure 4-4. The adjustment procedure is as follows:

a. One of the panel plug-in units must be in place.

b. With the POWER switch turned off, remove the cabinet from the FR-38/U. Figure 4-1 shows location of cabinet-securing screws.

c. Turn on the POWER switch and allow the equipment to warm up for five minutes. Turn the equipment so that the back of the power supply deck is accessible.

d. It is advisable that the line voltage from which the FR-38/U is operating be 115 volts ±2%. In any case the line voltage should not be less than 105 volts nor more than 125 volts.

e. First adjust the -195 volt supply. To do this, set a high-resistance d-c voltmeter such as the AN/PSM-4 to measure -195 volts dc and connect between ground and the green wire end of R-523 or R-526 (see Figure 4-4). Adjust R-524 until voltmeter reads -195 volts.

f. Next, adjust the +210 volt supply. Set the voltmeter to read +210 volts. Connect voltmeter between ground and the red wire end of R-502 or R-505 (see Figure 4-4). Adjust R-501 until voltmeter reads +210 volts.

g. Next, adjust +90 volt supply. Set voltmeter to read +90 volts. Connect voltmeter between ground and purple wire end of R-510 or R-509. Adjust R-509 until voltmeter reads +90 volts.

h. Finally, adjust the +70 volt supply. Set voltmeter to read +70 volts. Connect voltmeter test leads between ground and orange wire end of R-517 or C-346. Adjust R-516 until voltmeter reads +70 volts.

i. Since the settings are interdependent, the adjustments should now be checked and repeated if necessary.

4-10. TROUBLE-SHOOTING THE DECIMAL COUNTING UNITS Z-204 to Z-209. When a Decimal Counting Unit (DCU) is suspected of counting incorrectly, it should be interchanged with another unit in the equipment or replaced with a spare unit to determine whether the trouble is in the suspected unit or in the associated circuitry. This test should be made very carefully; the counting units are the indicating devices of the equipment, and faulty operation may be ascribed to them when the symptoms are actually the external indication of some other fault in the equipment.

4-11. Two methods are recommended for finding the trouble in a faulty counting unit. First, the lighting sequence can be observed while driving the equipment at a low repetition rate. Second, the waveform of each

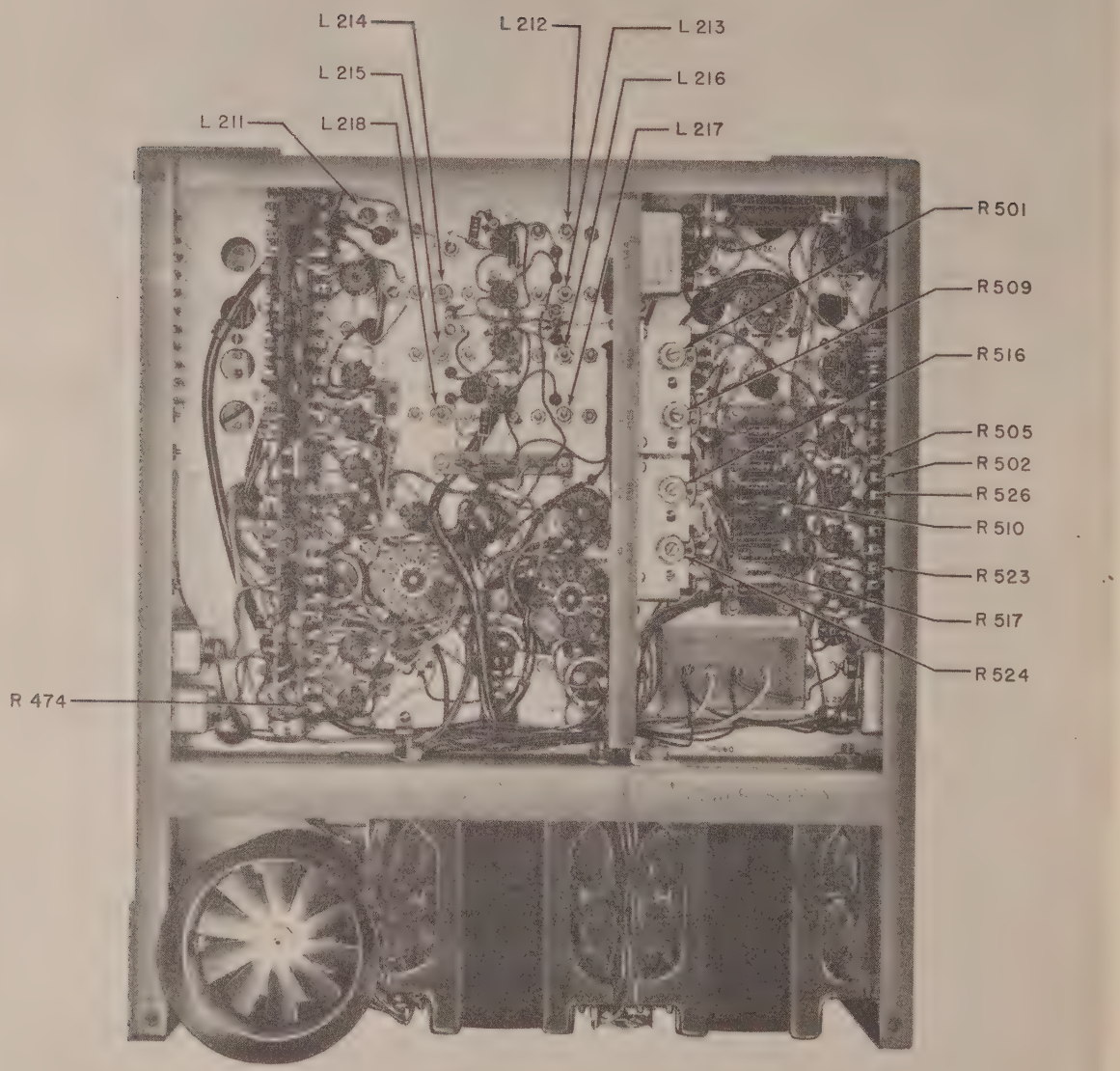


Figure 4-4. Frequency Meter FR-38/U, Rear View

stage can be studied while driving the unit at a repetition rate fast enough to be conveniently viewed on an oscilloscope. In difficult cases, both methods should be tried. Marginal failures may occur at high counting speeds and not at lower speeds, and vice versa. The first method is the only way that a neon lamp failure can be located, and it can be used to locate component and tube failures. For this reason, it is recommended that this method be used first.

4-12. In general, try replacing tubes first when it has been determined that a DCU is defective. Then check the +300 vdc unregulated source.

4-13. CLEANING CONNECTOR CONTACTS. If the contacts on the 8- and 16-contact plug-in connectors (P1, P2, J201, J202, etc.) become dirty, erratic counting may occur when measuring low frequencies of approximately 10 kc and below. This effect is usually noticeable when using low signal levels of 0.2 volt or so while the Frequency Converter unit is in place. With the power switch off, the contacts can be cleaned approximately once a month with a soft, lint-free, dry cloth.

4-14. In persistent cases, the cloth may be dampened with cleaning solvent, taking suitable precautions against possible explosion or fire.

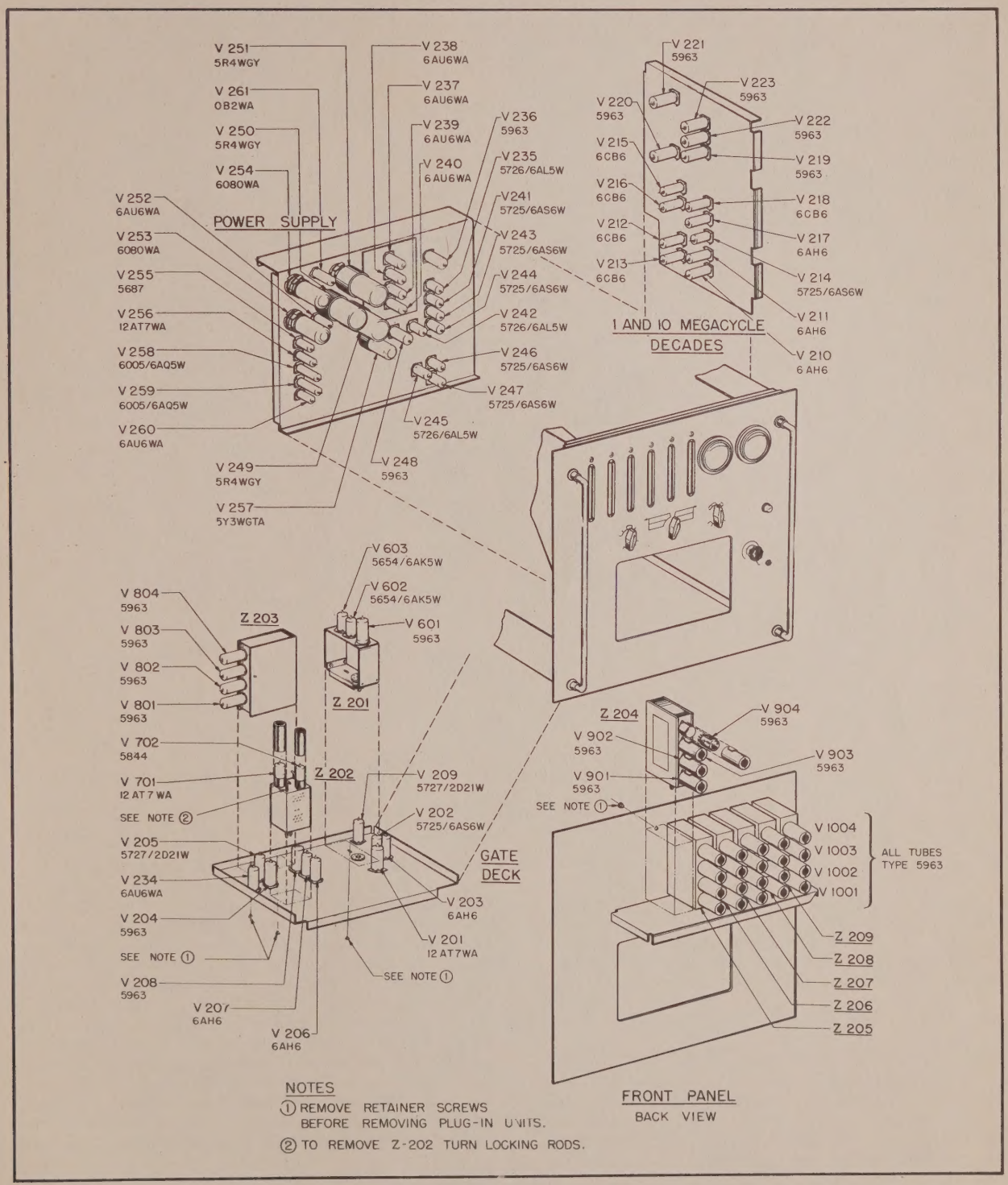


Figure 4-5. Frequency Meter FR-38/U, Tube Location Diagram

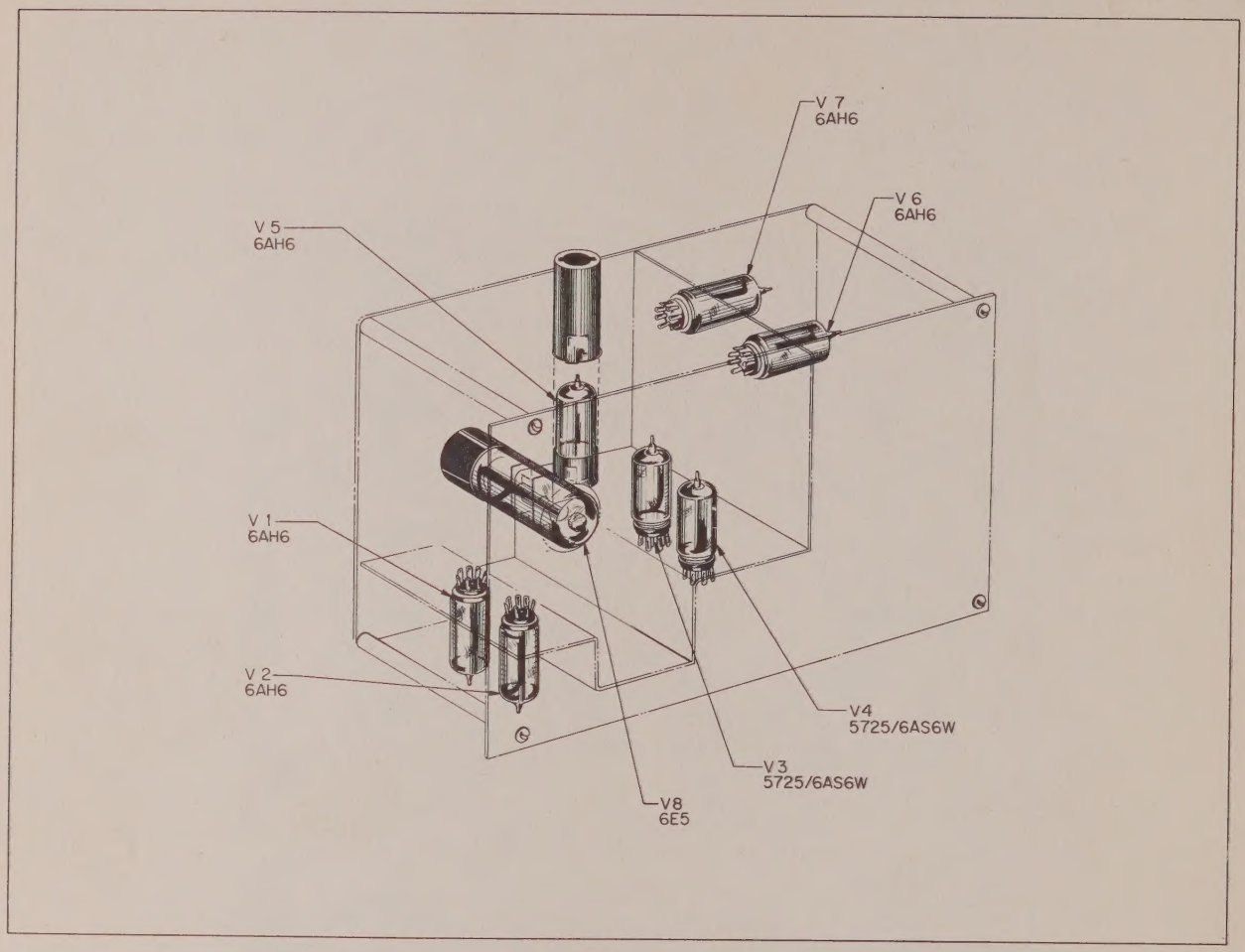


Figure 4-6. Frequency Converter Unit, Tube Location Diagram

4-15. ADDITIONAL ADJUSTMENTS.

4-16. If the adjustments described in preceding paragraphs do not restore satisfactory operation, other troubles are indicated. Major repair and trouble-shooting requires careful servicing and should be referred to the proper maintenance personnel.

4-17. EMERGENCY REPAIR.

4-18. LOCATION OF TUBES, FUSES, AND LAMPS. The location of tubes is shown in Figures 4-5, 4-6, and 4-7. The location of fuses is shown in the front panel illustration, Figure 2-1. Spare fuses are located in fuseholders on the front panel so that the blown fuse may be replaced from a spare fuseholder adjacent to the blown fuse. The pilot lamps (Figure 2-1) are Mazda #47, rated at 6-8 volts at 0.15 ampere, and can be replaced by unscrewing the jewel from the lamp-holder.

4-19. TUBE REPLACEMENT. In the event of equipment malfunctioning or failure, the equipment can be examined for obvious tube failure, i.e., cold tubes (burned-out filament), and the tube or tubes replaced. Weak tubes may also cause improper operation. If power supply voltages are checked and found normal, weak tubes may be replaced in circuits such as the phantastrons or power supply and require only minor circuit adjustments to again obtain satisfactory operation. If the replacement tube does not correct the operation, the original tube should be replaced in the socket. The procedures given in paragraphs 4-3 through 4-14 are, in general, those procedures that must be followed when replacing these tubes. Replacement of tubes in other circuits is not recommended unless the equipment can be given a complete servicing check.

4-20. AIR FILTER. The air filter element is a renewable type which can be cleaned by washing with a solution of ordinary household detergent and water. The filter should be inspected weekly and cleaned if the collected dirt is appreciable enough to hamper free air circulation.

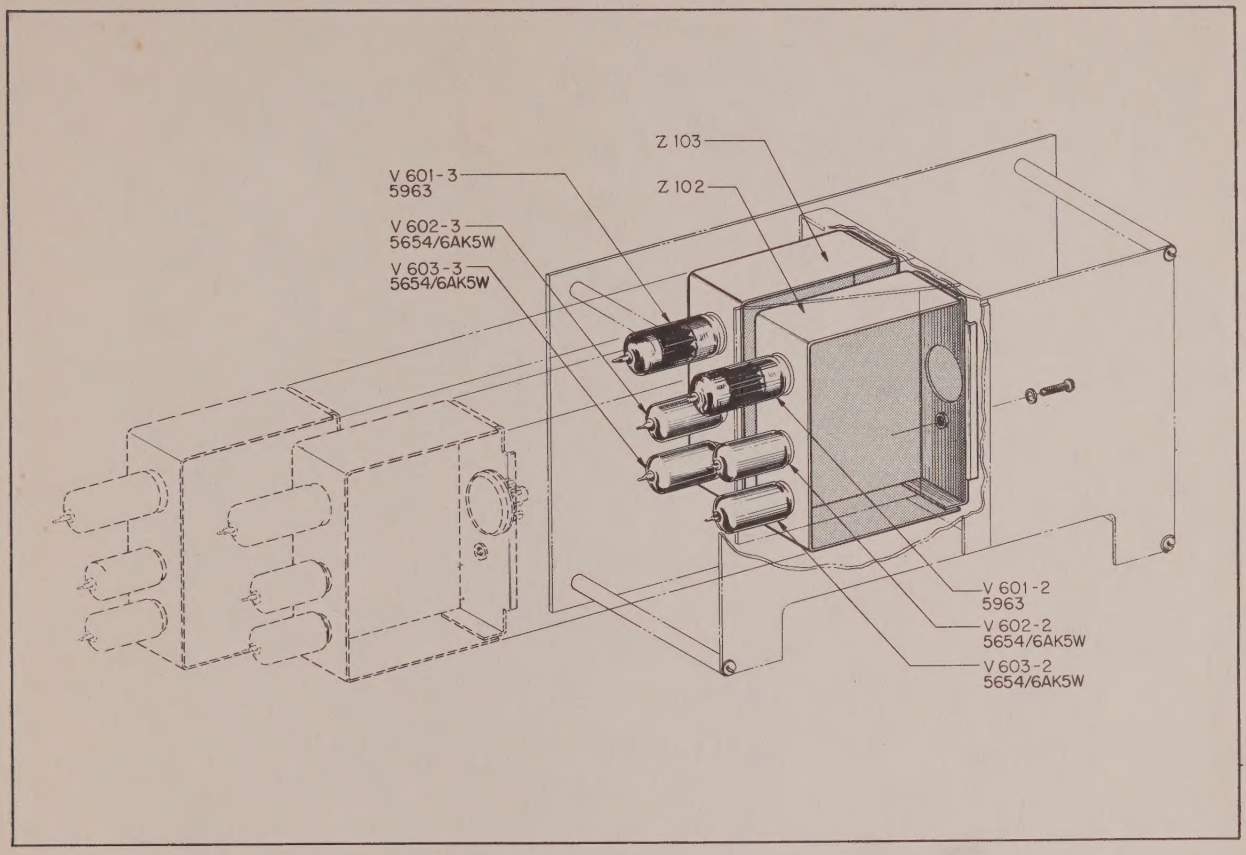
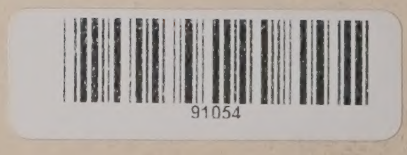


Figure 4-7. Time Interval Unit, Tube Location Diagram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